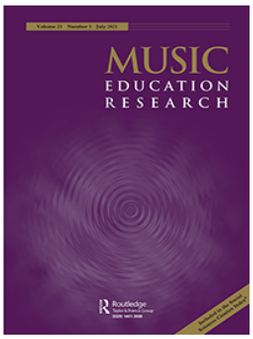

Music Education Research

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/cmue20

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Sati Doganyigit & Omer Faruk Islim

To cite this article: Sati Doganyigit & Omer Faruk Islim (2021) Virtual reality in vocal training: a case study, Music Education Research, 23:3, 391-401, DOI: 10.1080/14613808.2021.1879035

To link to this article: https://doi.org/10.1080/14613808.2021.1879035

MUSIC EDUCATION RESEARCH
2021, VOL. 23, NO. 3, 391–401
https://doi.org/10.1080/14613808.2021.1879035

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Virtual reality in vocal training: a case study

Sati Doganyigit[a] and Omer Faruk Islim [b]

[a]Department of Music, Kirsehir Ahi Evran University, Kirsehir, Turkey; [b]Department of Computer Technology, Mersin University, Mersin, Turkey

ABSTRACT

Vocal training is a specialist, multidisciplinary subject area that helps individuals to develop the behaviours and skills to utilise their voices effectively, properly and pleasantly based on abstract narration. Vocal trainers use abstract concepts in order to make corrective interventions during vocal training, and aim to create associations through imagery. This qualitative study aims to examine the impact of virtual reality on the use of vocals in the vocal training of music students at a Fine Arts Faculty, and their virtual reality experiences. The primary data of the study were collected via semi-structured interviews from eight students, and the secondary data were gathered from three voice trainers. Result of the study indicated that a more natural control of breathing was possible, resonance gaps were opened up, voice was produced at an upper level with vibrato in a more comfortable and easier way, and students produced a more powerful voice.

ARTICLE HISTORY
Received 13 April 2020
Accepted 16 January 2021

KEYWORDS
Music education; vocal training; virtual reality; 360 videos

Introduction

Vocal training is a specialist, multidisciplinary subject area that helps individuals to develop the behaviours and skills to utilise their voices effectively, properly and pleasantly when talking or singing depending upon the type/genre (e.g. soloist, choral) or level of their training (Töreyin 2008). Vocal training is based on abstract narration, and learners may be required to create a visual imagery in their minds through several examples from their previous life and learning experiences in order to assist them in producing the correct sound. For instance, they may imagine they are descending a ladder when aiming for high-pitched sounds or ascending a ladder when aiming for low-pitched sounds. This is because the vocal cords are located at an invisible point in the larynx, and learners try to produce sounds by using almost all of their bodies in addition to the actively used muscles. Although it is possible to see vocal cord movements in medical terms, learners cannot actually see their own vocal cords in the classroom environment. Hence, they are required to manage their voice as an instrument that they cannot physically see, which is in contrast to the playing of most other musical instruments (Davis 2017; Phillips 2011; Winnie 2014). According to Sabar (2008), a piano student sees the piano keys, and knows which key to press using which finger. This experience is also similar for musicians playing stringed or wind instruments. The musician holds the instrument, sees which tone to press using which finger, and at the same time checks the outcome upon hearing the resultant note. Yet, a singer carries their instrument within their own body. Therefore, in order to use their instrument effectively, singers need to first imagine the tone, visualise how the voice will be used in their minds, and then control their breathing

CONTACT Omer Faruk Islim islim@mersin.edu.tr Department of Computer Technologies, Vocational School of Mersin, Yenisehir Campus, Mersin University, Mersin, Turkey

mechanism in order to generate the correct tone, which in itself is a huge undertaking. Hence, it can be said that being a singer requires more time and effort compared to other musicians.

Vocal trainers use abstract concepts in order to make corrective interventions during vocal training such as 'push the diaphragm harder', 'do not press on the larynx', 'bring your voice forward', or 'think that you are throwing your voice to the other side of the room' (Sabar 2008; Winnie 2014). Through the giving of examples to facilitate these reminders, vocal trainers aim to create associations through imagery. The primary goal of vocal training is to provide functional freedom and freedom of movement. When speech organs react to previously studied conceptual images, it is possible to create the anticipated sounds automatically (Reid 1971). For this reason, the imagination method is crucial in such training in terms of properly guiding the muscles in order to activate certain reflexes (Phillips 2011; Winnie 2014). According to Helvacı (2005, 132), 'the main principle should be to transform vocal training practices and activities, which are known to be mostly abstract processes, into concrete practices and applications to facilitate learning and ensure retention'.

Linklater (2006) stated that use of regular images in the production of sound ensures the establishment of a connection between the body and the mind, and that these images in the mind stimulate emotions to start an action and turn it into a bodily behaviour (as cited in Yılmaz Davutoğlu 2015). According to Yılmaz Davutoğlu (2015), the sense organs play an important role in feeling the image that will help to produce the sound. Sense organs are therefore very efficient stimulators for human emotions and memory.

Davran (1997) pointed out that vocal training, which has virtually no tangible components, varies from student to student in terms of its methodology. Hence, one method may result in the creation of certain behaviours in some students at the perceptual or application stage, whilst the result may differ considerably for others. It is for this reason that the latter may experience a sense of anxiety, hopelessness, or in extreme circumstances, mental disorders.

Vocal training is conducted through various exercises and narration in order to stimulate certain behaviours. The success of vocal training depends heavily on a trainer's lecturing skill, as well as the student's ability to understand. Students should be able to understand and process the abstract concepts stated by the trainer in the same way that the trainer intended. Students are required to understand and interpret, which are abstract concepts of an example according to the associations and conceptions formed in their own mind as images. Nevertheless, sometimes students may create images that are the opposite to what their trainer visualised or intended, resulting in failure to achieve the desired result, and the student perceiving themselves as being unskilful or untalented (Phillips 2011; Yurdakul 2000).

One of the most important factors for success in local training classes is that trainers should get to know their students well. The personality of each individual consists of many varied characteristics, thus making it challenging for the trainer and thereby requiring them to provide a rich variety of examples in the classroom in order to suit the majority of the class. Since an example that positively impacts on some students may not mean much to others, this presents a significant challenge for trainers, necessitating a constant process of trial and error.

Although individual differences are considered as enrichment, in terms of training, it would seem logical for instruction to focus on the most common characteristics and perceptions of the individuals attending vocal training courses. According to Yurdakul (2000), students are particularly concerned about producing high-pitched voices for soprano and tenor sounds, whilst students fail to produce a quality tone since they exhibit bouts of anxiety, despite possessing an adequate vocal range as well as colours and techniques.

Since vocal training is based on abstract narration, different methods, techniques and visual materials should be used for the concretisation of abstract concepts in order to avoid the aforementioned problems (Phillips 2011; Winnie 2014). Especially with today's ever-developing technology, various materials can be used in local training which may positively impact on student learning (Hernández-Bravo, Cardona-Moltó, and Hernández-Bravo 2016). Many of these are innovative

methods such as augmented reality (AR) or virtual reality (VR), yet which might have been considered science-fiction or the product of someone's imagination just a few decades ago.

Virtual Reality (VR) has been commonly used in several areas of education, with applications helping users to feel relaxed as if in a different place or environment through the use of computer applications and specialist equipment. As in the real world, users may 'interact' within these environments and thereby strive to improve their knowledge and skills. There are several advantages of using VR in the educational context. One primary advantage is the ability to bring certain activities and actions into the classroom safely, such as those that are inherently difficult or dangerous to apply in real life within a classroom environment. VR also supports 'learning by doing', in that learners can experience certain cases over and over in order to concretise their learning of a certain topic (Dávideková, Mjartan, and Greguš 2017). VR also enables users to self-review their progress within a simulated environment by way of viewing recordings of their behaviours when using the VR environment so as to see their mistakes, which accordingly reinforces the learning process (Dávideková, Mjartan, and Greguš 2017).

Virtual reality has been applied in several areas of education, including medicine (Marks, White, and Singh 2017; Nicholson et al. 2006), dentistry (Dutã et al. 2011; Roy, Bakr, and George 2017), nursing (Gündoğdu and Dikmen 2017; Kilmon et al. 2010), aviation (Dreyer, Oberhauser, and Bandow 2014), engineering (Abulrub, Attridge, and Williams 2011; Häfner, Häfner, and Ovtcharova 2013; Sampaio 2012), mathematics (Kaufmann, Schmalstieg, and Wagner 2000), music (Bian 2016), and psychology (Gerardi et al. 2010).

The current study aims to create a similar influence by triggering student reflexes through the provision of training videos that are compliant with aspects of the art being studied according to each student's level, where students are able to create images in the mind, but through VR rather than reliance upon their imagination.

Method

The purpose of the current study is to examine the impact of virtual reality on the use of vocals in the vocal training of music students at a Fine Arts Faculty, and their virtual reality experiences. To this aim, answers are sought for the following research questions:

- Have students kept pace with the flow in the use of virtual reality?
- How does the use of virtual reality influence vocal use by vocal training students?

Research design

This qualitative study examines the impact of using virtual reality in the vocal training of music students, and also that of their VR learning experience. Qualitative studies aim to conduct in-depth analysis and definition of a specific case (Fraenkel, Wallen, and Hyun 2012; Yin 2011), and generally to reflect the study participants' opinions and suggestions (Yin 2011). As a case study, qualitative research methods involve various data collection methods or tools such as observation, interviews, document analysis or questionnaires in order to establish an in-depth understanding of one or more phenomena based on certain variables (Yin 2009). Case studies are preferred when research questions involve why and how questions, when researchers have limited or no control over the environment or phenomena, or the study examines some temporary phenomena (Yin 2011).

Participants

In the current study, data were collected from two different groups. Convenience sampling method was used for the selection of the participants, which is where prospective participants of a study are

Table 1. Demographics for Group 1 Participants.

ID	Gender	Age (years)	Voice type
S1	Male	20	Tenor
S2	Female	20	Soprano
S3	Female	19	Soprano
S4	Male	20	Tenor
S5	Female	19	Soprano
S6	Female	19	Soprano
S7	Female	19	Soprano
S8	Female	27	Soprano

selected based on their previous life experience or some specific characteristic they embody according to certain criteria (Fraenkel, Wallen, and Hyun 2012).

The first group (Group 1) consisted of eight voluntary participants studying in the Music Department of a Fine Arts Faculty, and who received vocal training for 2 h per week over a total of four semesters. Table 1 presents the demographics of Group 1.

The second group (Group 2) consisted of specialists who had evaluated the performance of Group 1. There were three participants in Group 2, who each held doctoral degrees in music education, and then continued their academic studies in the same area and now lecture on vocal training at the university. Table 2 presents the demographics of the Group 2 participants.

Data collection and analysis

Prior to the collection of data, the virtual reality application was developed. To this aim, the researchers named two musical pieces according to the levels and voice types of the participant students, along with specific sections of these musical pieces with which the students generally experienced difficulties in their vocal training. Piano accompaniment of the pieces was recorded based on the most appropriate tones for the students' voice types.

Next, a 360° video recording was selected for the application, trimmed according to the most difficult parts of the songs, and merged with a piano accompaniment. The virtual reality (VR) application was adjusted to start six measure before the start of one part, and eight measure before the other so as to allow time for the students to prepare themselves for the difficult part to start. In other words, the students would start to sing the song six or eight measure prior to the commencement of the difficult part of the song. The VR application was tested and approved by two vocal trainers prior to its implementation.

Samsung Gear VR glasses and an appropriately equipped mobile phone were used for the VR application. In the 360° video, the participants saw themselves sitting in the front seat of a rollercoaster and able to look around in all directions. When the application started, the rollercoaster moved ahead slowly. As it progressed closer to the difficult part of the song, the rollercoaster started to move at a downwards angle with increasing speed. As the rollercoaster reached the lowest (deepest) point of the rails, and at its fastest speed, the students heard the highest pitched notes of the song. Then, as soon as the low-pitched part of the song started, the rollercoaster started to move in an upwards angle and with correspondingly decreasing speed. When the rollercoaster reached the top-most point of the ride, and at its slowest speed, then students heard the lowest pitched notes of the song.

Table 2. Demographics for Group 2 Participants.

ID	Unit	Department	Area of Specialty	Service (years)
F1	Conservatory	Opera and Vocals	Vocal Training	38
F2	Conservatory	Opera and Vocals	Vocal Training	34
F3	Faculty of Fine Arts	Music	Vocal Training	13

Data for the study was collected from music students enrolled to a Vocal Training course during the 2018–2019 Spring semester at a Fine Arts Faculty of a state university in Central Anatolia, Turkey. Vocal training is taken as a one-to-one course where instructors conduct private sessions with each student according to a pre-agreed schedule, and students perform musical pieces they selected themselves along to piano accompaniment. In these sessions, the instructors, who each have vocal training expertise, provide their students with vocal exercises so as to improve their technical skill level, and guide them in order to apply these technical skills in their performances. One of the techniques used for enabling students to perform the piece in an easier and proper manner is use of their imagination in order to trigger certain required reflexes. Under normal circumstances, imagination varies individual to individual, and thereby not every student will produce the same anticipated vocal output. The current study aims to ensure that each participant student feels appropriately relaxed to the same extent by providing an environment suitable to trigger the required reflexes rather than merely leading them to using their imagination.

Data was collected during vocal training sessions as predetermined in the students' course programme. First, the students were asked to perform their selected musical piece with piano accompaniment, just as they had practiced on previous occasions and without any enhancement; so, just as they would do in any other session. Then, they performed the same piece but with the piano recording using the VR application. With the students' prior consent, both sessions were also video-recorded as data to be collected for this research. Individual interviews were then conducted immediately following each session.

The primary data collection tool of the study were semi-structured interviews, using questions and an interview protocol developed by the researchers. The proposed questions were prepared and submitted for review by two subject-matter experts, and then finalised according to their comments as a set of ten questions. Of these ten questions, two aimed to reveal the interviewees' prior knowledge and experience of VR, with six questions concerning their views about the impact of VR on their vocal training, and the last two questions on the potential usability of similar applications for other instructional courses. In addition, as a feature of the semi-structured interviews, the students were asked secondary or follow-up questions based on their initial answers in order to drill down where the researcher considered necessary to elicit the fullest response.

Each interview lasted for approximately 15 min, and was audio-recorded with the participants' prior consent. The audio files were transcribed by the researchers verbatim, and then coded using the Constant Comparative Technique and coded data analysis process of Miles and Huberman (1994). In other words, the researchers eliminated irrelevant texts from the raw material, reread the texts to deduct meanings from the interview transcripts, selected the meaningful data, determined the first-level codes, merged related codes to determine the themes of the coded data, and then developed a matrix consisting of the codes and themes (Miles and Huberman 1994). The researchers first coded the raw data file separately, and then compared and discussed their respective codes. Following a discussion, the researchers generated a coding table which was comprised of all the codes used, and then analysed the document to compare and discuss the coding. The researchers analysed the remaining documents using the matrix finalised at the end of these two sessions. Finally, the researchers evaluated all of the interviews following completion of the individual coding process. Both of the researchers work in the area of teacher training; one holds a Doctoral degree in Music Training, and the other in the discipline area of Instructional Technology.

The secondary data source of the study were the video recordings of the VR application. These recordings were reviewed by three vocal training specialists, who each held an appropriate Doctoral degree. Each of the specialists were asked to compare the regular performance with piano accompaniment (i.e. first session) with the performance supported with the virtual reality application (i.e. second session). The specialists watched the recordings in order, and their assessments were also audio-recorded, and then transcribed and subjected to content analysis.

Results

This section first reports on the students' views with regards to their previous experiences of virtual reality, the impact of VR usage in vocal training lessons, and the potential application of VR in other courses they are studying. Secondly, the views of the subject-matter experts who evaluated the performance of the students are reported.

Previous VR experience

Today's rapidly developing technology and decreasing technology costs have made VR generally accessible. Although high-quality, advanced devices and applications such as those offered by large companies (e.g. Oculus, HTC) are still beyond the reach of most people, VR can now be considered an accessible technology owing to smartphones and VR-embedded glasses. In addition, some entrepreneurs now provide opportunities to try out more professional, advanced products at a relatively modest price tag.

Despite the premise that VR can be considered as common technology, only two of the participants stated having any prior experience. However, their detailed explanations revealed that only one had any real prior VR experience.

Impact of virtual reality

The participants were asked about their views on the impact of virtual reality technology on their vocal training. Their responses indicated certain advantages of VR usage such as its perceived superiority over imagination, easier and more comfortable own voice usage, helping to achieve higher-range notes, more flexible transformation of the voice, more efficient usage of resonance gaps, generating stronger sounds, producing vibrato, triggering reflexes, easier breathing control, flowing, embodying, natural breath flow, producing sounds with the correct technique, increased self-confidence, and a generally accelerated learning process.

Embodying: superiority of virtual reality over imagination

When the participants are asked about the impact and advantages of VR usage in their vocal training, all of them ($n = 8$) indicated that VR was considered more effective than simple use of their own imagination. The participants stated that when only using their imagination in vocal training, they experienced difficulties in producing sounds to the expected quality, even where they knew how to hold the correct position. In addition, the students emphasised that failure to hold the right position added stress on the larynx and other parts of the body, resulting in rather forced vocal production.

On the other hand, when they used VR they did not feel forced to rely on their imagination, that abstract thoughts became tangible in front of their eyes, and that they were better able to produce vocal sounds of the expected quality. Additionally, the participants also indicated that VR usage in vocal training helped them visualise the image they were supposed to create in a clear and tangible way.

> Although I already knew the position before practice, I couldn't do it. But the application definitely helps us to keep the required position, and to apply it properly. At first, I felt that I stressed myself subconsciously. I could not fully control my breathing. But in the second session, I put myself within that [VR] application, my body and my nerves were reactive … and I was better able to keep my breathing controlled. How can I say it? Before, we had only abstract thought. It was easier this way [with VR] because it was more tangible. In our classes, we were trying to perform using our imagination, but here [VR] it was more tangible with visuals and video. I think it was better and clearer. (S4)

Easier and more comfortable vocal use

Another advantage indicated by all participants ($n = 8$) was easier and more comfortable vocal use owing to their VR vocal training. They stated being able to produce voices easier and more

comfortably in accompaniment to the rollercoaster in the application descending at speed with a high-pitched voice, and ascending slowly with a low-pitched voice. They particularly emphasised that high-pitched vocal production was much less painful compared to the problems they previously experienced.

> As we saw, parts of the video matched with parts of the music. We can do it easily because we feel like we are there. (S4)

> I was very comfortable. Normally, I have difficulty in reaching a high-pitched voice. Here, I was very comfortable with the high pitch. It makes you sing more comfortably. For instance, you go up to a high pitch, and also feel comfortable coming down. (S8)

Opening up resonance gaps and upper-level vocal production

Opening up resonance gaps and vocal production at the upper-range level was another impact of using VR for vocal training, as underlined by all of participants ($n = 8$). They stated normally experiencing difficulties in opening up resonance gaps, suffered blockage, and felt gaps were blocked and closed. However, with VR, they were able to open up resonance gaps more naturally and easily, and felt their voices always reaching the upper levels.

> I was able to open that part at the back of my head. You know how we normally open up our voices. It felt like I opened it up more and more. I felt like there was a balloon inside, and that balloon grew and grew. (S5)

> Definitely, those gaps are opened up naturally. (S4)

> I felt the voice at an upper level. Never felt it lower. (S3)

> Opened up more. And it was comfortable, nothing felt blocked. (S6)

Triggering reflexes

All of the participants ($n = 8$) emphasised that using VR in vocal training triggered their reflexes. They indicated experiencing difficulties in classical vocal training since they had to think and control many factors, including getting the right position to produce the right voice, breathing in and out correctly, opening up resonance gaps, thinking the voice at the front and up, and so on, which made them feel stressed and experienced difficulties control their breathing. They stated that with the VR application, they did all these tasks more naturally, without prior planning since the application already triggered their reflexes.

> I think it was a very good experience. I learnt that something I used to think was very difficult was in fact an easy thing to do. I learnt that I should not stress myself, I should leave everything in its natural flow, and then my body will do what is needed naturally. (S4)

> I did not even think about breathing. I naturally did it. I was very comfortable. And, the voice was coming from up. (S1)

> I did not even think about opening my mouth. It all happened naturally, automatically. I felt that it happened naturally. (S5)

Going with the flow

All participants ($n = 8$) stated that they felt like they were in that place in reality when using the VR application, and they just 'went with the flow'.

> It is very useful in terms of vocal production; you sing with much more confidence as if you are actually there. (S2)

> Sir, I really felt myself there. When the rollercoaster was going up, my voice opened up much better. (S8)

> I really felt myself there. As if my feet didn't touch the ground. It was like that. I mean I could feel it. I went with the flow. (S6)

Voice production

Six participants stated that using VR in their vocal training influenced their voice production. Three participants indicated being able to produce a stronger and high-volume voice with the VR application, while two said they vocally used the right technique, whilst one was able to produce a vibrato, and one stated 'shaping the voice'.

> I felt my voice vibrated when going downwards. (S7)
>
> The volume of my voice was much higher. (S6)
>
> My voice was stronger. It was swerving in my head. (S3)

Natural flow and breath control

Almost all participants ($n = 7$) emphasised the positive impact of VR in their vocal training on voice flow and control. They stated normally experiencing difficulties in breathing in, holding their breath, and breathing out; however, in using the VR application, they naturally breathed in and out without overthinking.

> I could not do it properly when using imagination only. I could not control my breath or high-pitched voice. But I felt really able to control my breathing in virtual [VR]. I did not even think about breathing. It was so natural, like I was breathing in daily life. (S5)
>
> Without the video, I stressed myself so; how should I say it, I could not use it [breath] actively. When I was watching the video, I was comfortable breathing in and out. I was breathing naturally. (S2)

Views on VR system and its usability for other courses

All participants ($n = 8$) stated that using VR in their vocal training was generally considered useful. However, only four participants indicated that it could be used for other courses, or would be useful for other courses. In addition, one participant stated it also had other benefits like increasing their self-confidence.

> I did not have confidence in myself before I used the [VR] glasses. It increased my self-confidence and also the power of my voice. It is very beneficial for one's voice. You sing more confidently, as if you are actually there. (S2)
>
> It can be used for other courses that require imagination; for instance, like classes where you give us similar examples. (S5)

Expert opinions

The second participant group comprised of subject-matter experts who evaluated the performance of the student participants of the first group. All of the experts ($n = 3$) indicated that using VR in vocal training was efficient and useful. They underlined specific benefits of using VR in vocal training, stating that students performed with better techniques, more comfortably, with more resonance, used their voice in the right position, with adequate mouth opening, with a more controlled stance, higher volume of voice, and reflected the actual tone colour.

> The classical session shows the student's talent, but you can see that they are inexperienced. It is clear that they will improve these skills, but gradually. It is obvious that they have a good talent. With the VR glasses, I can see that they fully use their body, head and all timbre features; I mean to the full capacity like an experienced singer, with 100% usage of tone colour, volume and performance. This difference of the same person, in the same year, on the same day, performing the same song shows how efficient VR can be. They can use all resonance areas, actual tone colour and full capacity volume. An incredible impact. Articulation is good, intonation is right, tone colour is there. Colour is very important. For instance, their voice may be there, but without any tone colour. Now, colour is there as well. (F1)

> It seems that the vocal training students performed descending and ascending passages more comfortably, more correctly in technical terms (more resonant/sonant and powerful) and efficiently when using VR glasses compared to classical sessions. Their voice is at the right position, at the right place, up in the front, with mouth opening at the right size. I believe it will contribute to flexibility of their voice. (F2)

> It seems that students can manage their diaphragm better, the voice is at an upper level and front, and more resonant. Register passes are not obvious, the voice is more connected, and the students could produce voice more comfortably. (F3)

Discussion & conclusion

Many researchers (Davis 2017; Davran 1997; Phillips 2011; Winnie 2014) state that the vocal chords used to produce our voice are located at the larynx, a body part that cannot be seen, and hence can be difficult to manage and control. According to the current study's results, participants stated the larynx being more relaxed with VR and having produced their voice more comfortably, whereas it was normally perceived as more difficult. Yılmaz Davutoğlu (2015) emphasised the importance of using images and sensory organs in voice production. Considering that participants stated their larynx being more comfortable and that they produced their voice more comfortably, it could be suggested that the VR application addressed more than one sensory organ.

Vocal training is based on abstract expressions, and although examples given in the classroom are understood by students, it may not always be possible for them to achieve performances to the anticipated quality and integrity. Helvacı (2017) pointed out that visual materials are not used in vocal training courses, whereas most students consider that using visual materials in the classroom positively impacts on the course, and contributes to solving potential problems in the learning process, as well as increasing students' motivation and interest. Helvacı also emphasised that visual materials may be used efficiently in today's classroom with advanced-level technologies. After having used the VR application, all participants stated that richer visual materials were used compared to classical vocal training where instructors provided only abstract examples, and they were able to visualise images otherwise difficult to achieve through mere imagination. The use of VR influenced their concretisation of abstract concepts, as well as their stance and mimicry.

Linklater (2006, as cited in Yılmaz Davutoğlu 2015) and Sabar (2008) indicated that certain reflexes should be triggered to correctly facilitate voice production, and that imagination should be used to ensure this process. Nevertheless, Davran (1997) and Yurdakul (2000) emphasised that it might not be possible for every student to understand abstract concepts given by instructors, leading to their failure for perform the anticipated behaviour. Since the VR application provided a visual flow in parallel with the parts of the musical piece, there was no need for students to try to visualise images in the mind. This method thereby helped to smooth over the impact of students' individual differences, trigger common reflexes in all students, and ensure an easier and more comfortable voice production.

The use of VR in vocal training assisted the participants in being actively involved in the flow of the VR environment and triggered their reflexes. As a result, a more natural flow and breathing control was possible, resonance gaps were opened up, their voices produced at an upper level with vibrato more comfortably and easier, and they produced a more powerful voice at a much higher volume. Hence, instead of having voice organs react to prestudied conceptual images, which was considered the primary purpose of vocal training by Reid (1971), the current study's students were provided with real images during training that automatically triggered reflexes, ensuring a faster and better vocal production at the anticipated level, without need for additional repetition.

This current study was limited to eight soprano or tenor Music department students of a Fine Arts faculty. Their knowledge and skills training was limited to 2-hour formal weekly vocal training sessions lasting four semesters. The findings of the current study were also limited as based only on two musical pieces. Finally, the VR application used was limited to a 360° rollercoaster video.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

Sati Doganyigit is an assistant professor in the Faculty of Fine Arts at Kirsehir Ahi Evran University, Turkey. She got her PhD Department of Music Education from Konya Necmettin Erbakan University. Her research focused on music education, vocal training, and mutation period.

Omer Faruk Islim is an assistant professor in the Mersin Vocational School at Mersin University, Turkey. He got his PhD Department of Computer Education and Instructional Technology from Middle East Technical University. His research focused on technology enhanced learning, instructional technology, instructional design, gamification and game based learning.

ORCID

Omer Faruk Islim http://orcid.org/0000-0002-9520-043X

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