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Using mobile applications in the study of vocal skills

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Abstract
This article reflects the results of a study involving second- and fourth-year students from Harbin University (Harbin, China), the Chinese Academy of Arts (Hangzhou, China), and the Central Academy of Drama (Beijing, China). The work analyzed the impact of specialized mobile applications Vox Tools: Learn to Sing and Swiftscales Vocal Trainer on the vocal learning process, depending on the age and gender of students. The study, which ran from February to June during the academic year 2020-2021, involved 180 students. The study confirms the effectiveness of multimedia, demonstrating the higher scores of the experimental groups on the five assessment criteria, compared with the control groups, which did not use mobile applications. It was also found that age in two groups of students (second and fourth year) had no effect on performance, regardless of whether the mobile app was used for vocal training. A correlation was found between age and overall student performance, with second-year students showing lower grades in all groups compared to their fourth-year counterparts. Research on current mobile vocal training apps can help improve vocal learning.

Keywords Vocal training · Music education · Mobile learning systems · Interactive environment · Mobile applications · Vocal skills

1 Introduction

Vocal training is a specialized, multidisciplinary subject area that helps people develop the behaviors and skills to use the voice effectively and correctly. Vocal instructors use abstract concepts to make adjustments during vocal training (Doğanyiğit & Islim, 2021). Voice is practiced in performance, especially in relation to new media, new stage and everyday architectures, and new hybrid genres and aesthetics. Voice pedagogy a few years ago involved the production of vocals

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through canonical poetic text, but contemporary scenarios or music training have felt the influence of interactive technologies (Thomaidis, 2019).

The learning environment for vocalists currently functions through a variety of instructional programs, including specialized ones (Tian, 2020). More and more musical disciplines are now being integrated with modern educational ideas and methods, using multimedia technology as well as performing and visual arts (Yang, 2021). The education industry is using its own new ideas to promote music education (Chen et al., 2019). Media environments have benefited the field of vocal education by creating resources that provide students and all musicians with opportunities to connect with one another, share their skills, and improve their abilities (Wash, 2019). Bringing music to life through digital technology is changing music making.

New educational scenarios appear with the use of information computer technology (Bolívar-Chávez et al., 2021). As an important way of digital education, interactive education is not only widely accepted, but has long been considered an important focus of the educational regime (Xu & Zhai, 2022).

To keep up with the pace of vocal teaching worldwide, teaching methods must also be constantly updated. Singing instruction is a subject of constant practice that requires constant teacher-student interaction. However, traditional methods can also be used in teaching, and they can be firmly rooted in tradition, and constant updates can lead to ignoring the centuries-old tradition of successful voice learning (Costanza & Russell, 2017). Based on this, it is concluded that modern voice learning should be based on a combination of traditional and innovative methods to preserve centuries-old tradition and at the same time update methodological approaches, the use of which requires pandemic conditions in which modern learning develops. However, in today's COVID-19 pandemic, personal contact is not always possible, or entails the threat of spreading viral infection. In a pandemic, mobile learning technologies and applications are used in all areas of education (Crompton, 2013).

Mobile apps and modern programs in music education can meet the needs of the music community by fostering collaborative discussion, deeper music learning, and cognitive development. Dedicated technology can be an effective tool for enhancing learning by providing students with personalized instruction (Xu & Zhai, 2022). In China, research has been done on finding technological solutions to improve and modernize music education aimed at developing fundamental vocal skills using mobile apps (Shi, 2021). A simulator with real-time visualization has also been developed to evaluate results and errors in vocal training (Zhang, 2021). Data from the work over the past year show a growing interest in the use of interactive platforms for vocal training in the context of educational institutions, which confirms the relevance of such research.

This article is an original study of the effect that modern mobile apps have on vocal instruction, demonstrating their impact on the canonical foundations of the instruction and enabling students to learn vocal using a variety of information channels. This study aims to clarify questions regarding the effectiveness of current mobile apps. At the same time, this study can be seen as complementary to

previous studies on the effectiveness of mobile apps in vocal training, the most effective apps, and the impact of age and gender on vocal training success.

2 Literature review

E-learning is a key activity in today's knowledge-based and networked society. With digital technologies at the heart of the networked society, higher education institutions create and disseminate knowledge and make a crucial contribution to student learning. Not surprisingly, e-learning has experienced rapid growth since its emergence in the mid-1990s and is rapidly evolving (Rodríguez-Ardura & Meseguer-Artola, 2016). Generating ideas through an interactive learning environment requires consideration of technical and material aspects. Creative use of technology is supported not only by digital devices, but also by tangible technologies such as educational robotics and mobile applications that organize the creative process (Alimisis et al., 2017). Mobile learning (mLearning), which became an established term in 2005 (Crompton, 2013), is now considered a distinct area of e-learning practice and research, and has become widely recognized worldwide (Bannan et al., 2016). It provides an opportunity to cross boundaries, to bridge the gap between formal and informal learning through a person's everyday use of mobile technology (Khaddage et al., 2016). In terms of organizing learning, integrating personal mobile devices into the education system is a challenging task. One of the problems of integrating mobile devices in education is related to the definition of formal and informal learning.

The traditional concept of education is undergoing global change; technological advances and IR 0.4 have improved the structure of education through the introduction of devices such as laptops, tablets, and smartphones (Qureshi et al., 2020). In today's world, there is a transition to modern teaching methods involving the use of wireless state-of-the-art technologies in the teaching and learning environment, which has become especially popular since the beginning of the COVID-19 pandemic (Bolívar-Chávez et al., 2021). Mobile and computer-based learning developed from this idea is one of the most important advances in improving the efficiency and effectiveness of learning (Talan, 2020). Technological advances allow students to increasingly use cell phones and computer programs for educational purposes and to create a suitable learning environment for music (Magalhães et al., 2018).

The field of research on learning has yet to present results that support the integration of mobile devices in education in the long term. This can be explained by the fact that most studies are based on short-term projects. Chinese researchers showed that of all 110 studies included in the sample, more than 27.2% were conducted within one week, and that only 8.3% of the research processes lasted more than six months (Sung et al., 2016). The widespread development of mobile technologies that were not originally designed for educational purposes can affect their integration into education because of possible technical obstacles (Yang & Xie, 2013). Research findings indicate that there is a need for more sophisticated

curriculum development to leverage the educational benefits possible more thoroughly with the introduction of mobile devices (Sung et al., 2016).

Researchers associate student engagement with interactive environments because students have more control over their educational process and therefore their requests are more relevant. Several pedagogical issues also come to the fore, which can be responded to by increasing understanding of information behavior in a high-tech environment. These concerns are directly related to a student's activities and include the transfer of control from a teacher to a student and informal learning activities that are usually done with minimal guidance. Thus, the research demonstrated that students associate freedom of action with a sense of autonomy, i.e., independence from teachers and parents. The study participants stated that their learning methods were chosen by themselves, and that smartphones became something more than tools with which they see and perceive the world (Chan et al., 2015).

Other researchers claim that educational mobile technology apps promote autonomous learning among students (Prieto et al., 2016). Students monitor their learning activities without teacher involvement, through their cell phones (Santos & Ali, 2012). Researchers from the United States studied teaching and learning with mobile computing devices simultaneously at three U.S. institutions of higher education and showed that learning was facilitated by rapid access to information, social media, mobile apps, and learning materials (Gikas & Grant, 2013). Researchers from China, in their attempt to understand how children use mobile technology (e.g., smartphones) to explore different learning environments and use a combination of resources, have shown that mobile technology can facilitate learning. This happens when students develop the habit of using cultural, epistemological, and social resources in their minds to develop connections between formal and informal practices, and when the use of mobile technology is within the broader knowledge bases that the current formal curriculum recognizes (Toh et al., 2017).

2.1 Vocal training

The American Academy of Teachers of Singing has found it important to encourage its members to adopt an expanded, systematic, practical approach to teaching different genres. Although many singers perform successfully in both classical and alternative styles, the vocal techniques required to produce these styles are hardly interchangeable. Vocal techniques were developed and used in a variety of vocal literature, including opera, oratorios, national and international art songs, and certain spiritual and secular music. Unfortunately, methods of singing in other genres such as folk, blues, jazz, pop, and rock have not been clearly defined or seriously addressed in traditional texts on vocal pedagogy. While it is true that all singers must breathe, sound, resonate, and articulate, they do not necessarily approach these technical elements in the same way. Acoustic, physiological, and pedagogical research challenges the widespread belief that classical vocal techniques alone can serve the variety of singing styles in the world (Bartlett, 2014).

Music courses provide highly specialized instruction to help students become proficient musicians. However, the traditional model of personalized instruction is limited geographically and financially, creating a need to find ways to address the limitations and adapt to the new pedagogy, which involves a paradigm shift and the development of new teaching methods and ideas (Johnson, 2016). A common practice in vocal training is the use of vocal exercise techniques involving partial occlusion of the vocal tract (Bele, 2005). Vocal health is important for a large segment of society, but especially for singers, vocal coaches, actors, and others who require a developed voice. The demands on the vocal mechanism can be high, as people in these professions perform speaking and singing assignments with frequent intervals. In addition to the heavy vocal load, performances may take place in difficult acoustic conditions.

Online technology can meet the needs of the music community, provide opportunities for musicians to discuss together, and foster deeper music learning and cognitive development (Johnson, 2016). A concrete example of the use of technology in music education is the use of software, which can provide a more continuous learning experience by allowing users to learn and practice at the desired level and amount (Nart, 2016). Technology has benefited the field of music education by creating resources that provide students and all musicians the opportunity to communicate and share their skills (Wash, 2019). Also, for research of this nature, it is necessary to establish within a theoretical framework what kind of learning ecosystem can be analyzed in a particular context, whether it is mobile learning, e-learning, crisis e-learning, or software, as this aspect is important to understanding the nature of the research (Turbot, 2021). In this work, the decision was made to use a mobile learning ecosystem that the students themselves used, but their progress was monitored through the software that was involved in the study.

2.2 Mobile applications used in music education

Mobile applications have a significant impact on the adoption and increased use of mobile devices, and mobile applications are commonly understood as mobile software designed to help users perform certain tasks (Song & Kim, 2015). Music is one area of experimental research showing that mobile apps are an effective tool in developing students' various musical abilities (Palazón & Giráldez, 2018). With the addition of mobile devices to the learning environment, one can state that physical limitations are eliminated, and learning becomes faster and more accessible, special environments are created (Demirtaş & Özçelik, 2021).

Specifically, Birch (2017) investigated the usability of SoundCloud mobile app, and it was found that students had increased motivation, extracurricular learning activities, and confidence. Another research paper (Chen, 2015) investigated the impact of using mobile apps on the development of listening skills using the Aural-book app, it was concluded that the use of mobile apps increased motivation and music skills. Another mobile app Harmonia-on-the-Go studied was used in the context of students learning music theory and found that the use of mobile apps had a

positive impact on student success and motivation (Chong, 2019). All of these studies show that the use of mobile apps makes a significant contribution to the study of music when participants in these studies used a mobile app for a specific purpose under the guidance of a researcher (Demirtaş & Özçelik, 2021). Considering the mobile applications already discussed, it is interesting to look in the direction of research toward applications that might increase the very success of vocal education, which would entail a higher level of training for future performers.

2.3 Problem statement

The main motivation for writing this paper is the desire to obtain new experimental data on the impact of modern technologies on the vocal learning process, as the results may influence the introduction of mobile applications in classical university programs, which will improve the quality of education for students and create new interactive learning forms.

The main purpose of this study was to examine the effectiveness of using specialized mobile applications Vox Tools: Learn to Sing and Swiftscales Vocal Trainer for vocal training, to determine what impact the applications had compared to a control group that learned vocal skills without the use of additional programs. Another goal is to identify the influence of students' gender and age when using mobile apps.

Before starting the study, the following objectives were formed:

(1) Analyze the effectiveness of using mobile applications in vocal training, identifying three groups: control group-A (classes are held directly according to the curriculum of the educational institution), group-B (additional use of the application Vox Tools: Learn to Sing) and group-C (additional use of the application Swiftscales Vocal Trainer). To track the effectiveness of mobile applications in comparison with the classical system without the use of special programs.
(2) Explore which mobile app has been shown to be more effective in improving voice skills and professional vocal techniques.
(3) Identify the influence of year of study and gender on the success of vocal training.

Table 1 Author's research scheme

Group	Impact
group-A (control)	classical system
group-B	classical system + Vox Tools: Learn to Sing
group-C	classical system + Swiftscales Vocal Trainer

3 Methods and materials

Below is the author's scheme, which shows how the experiment was conducted (Table 1).

The study used two mobile vocal training apps: Vox Tools: Learn to Sing and Swiftscales Vocal Trainer, both of which are available on both the iOS and Android platforms, which was a cornerstone factor in choosing the apps. It should be noted that no company-creator is an interested party in the research, and the authors have no personal benefit from mentioning the names of the programs. The use of the applications is dictated only by scientific interest in the research topic and is not an advertising move. The main criteria for selecting applications were the availability of functions for vocal distance learning, which was an advantage in a pandemic, the ability to conduct group and individual classes, the function of tracking students' minutes of study and academic performance. Other programs were not considered when choosing training applications. Students used applications in the learning process as an additional component of distance learning to improve vocal skills and competencies. In the applications, students had the opportunity to record the time spent studying and determine their own level of success. The applications did not provide feedback on their effectiveness and did not provide a structure for practice, and we determined the effectiveness of learning using applications based on indicators of academic performance of students, and the structure for practice was developed by us. We have not been held responsible for the practice of application developers.

The Vox Tools: Learn to Sing app (Fig. 1) is a fully managed training section with various programs created by vocal coaches for both men and women. In the initial stages of the setup, one must select a singing voice: tenor, baritone, bass, soprano, mezzo-soprano.

The program presents an advanced tool for vocalists and vocal teachers, with which one can perform individual training. There is a virtual piano, direct access to the blog (in Spanish), where one can find many tips to improve the quality of the voice. The application is 100.1 megabytes in size and is compatible with iPhone, iPad, and iPod touch. Available languages: English, Catalan, Spanish, age limit 4+. It is a free app (Vox Vocal Studio, 2019).

The Swiftscales Vocal Trainer app was created by singers for singers and is the first app to simulate sitting at the piano with a vocal teacher. One can control each session in real time, the only limitations are the 88 piano keys and imagination. In fact, vocal coaches themselves can use Swiftscales Vocal Trainer to teach students with exercises they are already teaching, thanks to the app's flexibility, extensive customization and cloud sharing capabilities. The app is 57.7 megabytes in size and is compatible with iPhone, iPad, and iPod touch. Available language is English, age limit 4+. It is free (Velden, 2019) (Fig. 2).

The study deals with the concept of vocal skills, which were developed using modern mobile applications. Therefore, the study involved the development of the following important skills, namely pitch control, vocal cord support

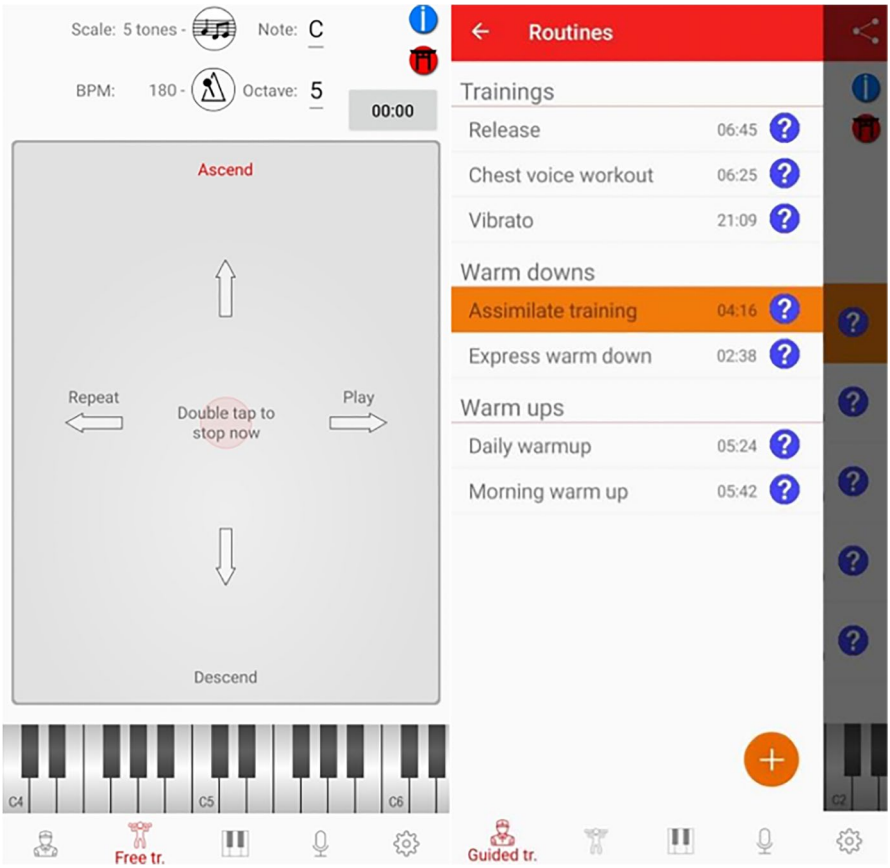

Fig. 1 Vox tools: learn to sing application interface

skills with special techniques, the ability to be aware of the volume and style of one's sound, the development of self-organization, and awareness of one's singing voice (Elson, 2022). The research tools were a research plan prepared in advance, instructions to all teacher-researchers as the study was conducted simultaneously in multiple locations, and a statistical data processing program.

3.1 Participants

The study, which ran from February to June during the academic year 2020-2021, involved 180 students from three institutions: Harbin University (Harbin, China), the Chinese Academy of Arts (Hangzhou, China), and the Central Academy of Drama (Beijing, China). Sixty people from each educational institution were involved. The basis for choosing these three schools for empirical research was the presence in the curriculum of a subject for the study of vocals and music. They were divided among themselves according to the study year: 2nd year (30 people) and 4th year (30

Fig. 2 Swiftscales Vocal Trainer application interface

people). Thus, six large groups of 30 people each were formed, which were subsequently divided into three more groups: Group-A practiced vocals according to the classical system without using applications, Group-B used, in addition to the classical training system, the mobile application Vox Tools: Learn to Sing, Group-C used, in addition to the classical training system, the mobile application Swiftscales Vocal Trainer. There were 10 students in each mini group. The control of experimental data in three groups was performed by three teachers who participated in the organization and conduct of the experiment, as well as coordinated the work and controlled the experimental data. Accordingly, the homogeneity of the experimental and control groups was monitored by these three teachers, who kept in touch so that the work was coordinated. The experiment involved three instructors for each study group who were unfamiliar with the respondents and had not taught in them before. Therefore, their independent activities provided internal and inter-valued reliability.

Teachers-instructors were objective in assessing students, so there was no difference in the assessment of respondents from different groups and, as a result, the difference between levels of classes cannot explain the difference in assessments between teachers. In addition, the objectivity of teachers meant that their rating was not biased due to their knowledge of the use of applications by students. There were no objective or blinded measures to improve the voice. The participants were chosen voluntarily by sending invitations to e-mails provided by the university administration. A person who showed interest in the research was automatically involved. The division into

Table 2 Information about respondents' gender in each of the mini groups

Group A (Harbin University)	
2nd year	4th year
Men – 40%	Men – 50%
Women – 60%	Women – 50%
Group B (Harbin University)	
2nd year	4th year
Men – 40%	Men – 30%
Women – 60%	Women – 70%
Group C (Harbin University)	
2nd year	4th year
Men – 50%	Men – 40%
Women – 50%	Women – 60%
Group A (Chinese Academy of Art)	
2nd year	4th year
Men – 50%	Men – 40%
Women – 40%	Women – 60%
Group B (Chinese Academy of Art)	
2nd year	4th year
Men – 50%	Men – 40%
Women – 40%	Women – 60%
Group C (Chinese Academy of Art)	
2nd year	4th year
Men – 40%	Men – 30%
Women – 60%	Women – 60%
Group A (Central Academy of Drama)	
2nd year	4th year
Men – 40%	Men – 20%
Women – 60%	Women – 80%
Group B (Central Academy of Drama)	
2nd year	4th year
Men – 60%	Men – 60%
Women – 30%	Women – 40%
Group C (Central Academy of Drama)	
2nd year	4th year
Men – 50%	Men – 30%
Women – 50%	Women – 70%

groups A, B, and C was random. The participants were 18 to 23 years old. The average age of second-year students was 19 years old, and the average age of fourth-year students was 22 years old. Of the 180 participants, 3 (2 women and 1 man) completed participation in the program early for personal reasons; their results were not considered. Detailed information about respondents' gender in each of the mini groups is shown in Table 2.

3.2 Research design

Each of the B and C groups received a one-hour tutorial from university vocal coaches on how to use one of the programs, and the students were informed that if they had any questions about the functionality of the app, they could contact vocal coaches for any information. The study was conducted over a five-month period, with all students taking standard vocal lessons, depending on the curriculum, and groups B and C taking an additional hour twice a week on apps. It was reported that some students spent more time on the app than the test program required. The high productivity of the experimental group is explained by the use of APP, rather than additional study time, as students had the opportunity to use mobile applications not only in class, but at any time. The use of mobile applications is characterized by efficiency, as it allows to improve the level of professional competencies and skills, regardless of additional study time. The sham treatment control group was not involved in the experiment, but one of the conditions of the training was the requirement for students to record the number of minutes devoted to learning using mobile applications. The time of study was recorded by students, which gave us the opportunity to evaluate and analyze it. Therefore, the results obtained are related to the use of the program, rather than increasing the amount of time practicing. They attributed this to the fact that the process of practicing singing was exciting and interesting, which influenced their voluntary desire to improve their vocal skills.

At the end of the study, each individual university's vocal instructor performed a group-by-group review according to a common curriculum. Vocal scores were given on a five-level scale, with 100-90 being excellent, 89-80 being good, 79-70 being mediocre, 69-60 being satisfactory, and below 60 being unsatisfactory. The evaluation criteria were as follows: work in class, homework (independent work), module control (vocal performance, according to the curriculum), group work (vocal performance in group), the final control (exam).

3.3 Data analysis

A test factor analysis framework was used to control the data from this study. Fisher's exact test (p) was used to check the collected data. All data were found to be satisfactory according to the criteria for comparative analysis proposed by statisticians. When using Fisher's test, the adequacy and validity of the data were ensured. The data from each student's individual record form that was filled out in the assessment were put into the SPSS Statistics program, and they were evaluated by statistical analysis.

3.4 Ethical issues

This study was professionally designed, properly executed, and approved by the administrators of all participating universities. A research protocol was developed and followed by all participants and administrators before research activities began. Participation in the study was carefully coordinated with all participants, and the anonymity of personal data was guaranteed. Approval of institutional review boards was also obtained.

4 Results

A test factor analysis framework was used to control the data from this study. A hierarchical linear model was used to test the data collected, which allows conclusions to be drawn as to whether there is a significant difference between the three groups (A, B, C). All data were considered satisfactory according to the criteria of comparative analysis proposed by statisticians. When using a hierarchical linear model, the adequacy and validity of the data were ensured.

The following paragraphs present the results for each research objective. Since research objectives 1 and 2 identify the extent to which the use of apps in vocal instruction is effective, it is necessary to consider the analysis of assessment data according to the selected criteria. After reporting on the analysis of student evaluation data, an analysis of grades by gender and age of study participants was performed to address research objective 3.

Table 3 shows the performance of second-year students in vocal lessons at Harbin University, Chinese Academy of Arts, and Central Academy of Drama according to selected assessment criteria by gender and mini group at the end of the study (June 2021). The average age of the 2nd year students was 19 years old. All p values are below 0.05, which is the threshold, thus the differences between the scores are significant.

The lowest scores were for mini groups A that received classical vocal instruction without the use of mobile apps at all three institutions: 75.3, 74.3, and 73.8, with an average of 74.5. On the contrary, mini groups B and C showed higher scores. Thus, students from mini groups B who were additionally users of Vox Tools: Learn to Sing got the following marks: 79.6, 79.7 and 78.9, the average

Table 3 Second-year students' scores for the three universities under study on selected assessment criteria by gender and mini group

Evaluation Criteria	Gender	Harbin University			Chinese Academy of Arts			Central Academy of Drama			Mean
		Grades on a 100-point scale									
		A	B	C	A	B	C	A	B	C	
1. Work in class	♂	68	70	71	67	72	75	69	70	71	70.33
	♀	71	72	69	73	75	69	74	72	78	72.56
2. Homework	♂	74	75	77	72	74	71	70	74	77	73.78
	♀	76	77	81	75	76	80	74	77	82	77.56
3. Modular control	♂	72	79	80	73	80	80	75	79	78	77.33
	♀	71	81	85	74	82	81	79	81	80	79.33
4. Group work	♂	79	88	87	74	84	86	72	85	85	82.22
	♀	81	89	87	79	84	88	76	86	85	83.89
5. Final control	♂	80	81	87	79	84	86	74	83	84	82.00
	♀	81	84	90	77	86	87	75	82	85	83.00
Mean		75.3	79.6	81.4	74.3	79.7	80,3	73.8	78.9	80.5	X
p value		0.021	0.019	0.031	0.041	0.023	0.029	0.047	0.042	0.036	X

score being 79.4, which is 6.5% higher than the control group. The mini groups C students who were users of the Swiftscales Vocal Trainer mobile app demonstrated scores of 81.4, 80.3, and 80.5, with an average score of 80.7, which is the highest of all groups, and 8.3% above control. Based on these data, one can

Table 4 Grades of fourth-year students at the three universities under study according to selected assessment criteria by gender and mini group

Evaluation Criteria	Gender	Harbin University			Chinese Academy of Arts			Central Academy of Drama			Mean
		Grades on a 100-point scale									
		A	B	C	A	B	C	A	B	C	
1. Work in class	♂	74	78	78	79	81	80	81	84	83	79.78
	♀	71	74	76	74	80	78	80	82	84	77.67
2. Homework	♂	78	82	84	79	80	79	74	80	80	79.56
	♀	78	83	85	80	80	82	76	81	78	80.33
3. Modular control	♂	78	81	83	78	84	81	77	89	89	82.22
	♀	79	79	84	78	85	82	79	81	83	81.11
4. Group work	♂	82	79	80	82	88	86	81	84	83	82.78
	♀	81	82	83	82	86	83	82	87	88	83.78
5. Final control	♂	83	84	85	82	86	86	87	87	87	85.22
	♀	84	86	90	84	85	85	85	86	87	85.78
Mean		78.8	80.8	82.8	79.8	83.5	82.2	80.2	84.1	84.2	X
p value		0.027	0.021	0.036	0.031	0.040	0.020	0.024	0.031	0.041	X

conclude about the effectiveness of the use of mobile applications in the context of vocal training of students. Second-year students performed better with the Swiftscales Vocal Trainer app, although the difference with the Vox Tools: Learn to Sing app was 1.8%.

As for the gender specifics: according to the results of the study male students showed lower results in all groups and for all criteria. Thus, the average score of male students was 77.1, while female students had this indicator at the level of 79.2. The difference between the genders was especially noticeable when evaluating the criteria "work in class" and "homework".

Table 4 shows the results of fourth-year students' performance in vocal lessons at three universities according to selected assessment criteria by gender and mini group at the end of the study (June 2021). The average age of the fourth-year students was 22 years old. All p values are below 0.05, which is the threshold, thus the differences between the scores are significant in this study as well.

In this case, as in the case of the second-year students, the lowest scores were obtained by mini groups A, which were controls and did not use specialized mobile applications: 78.8, 79.8, and 80.2, with an average of 79.6. Mini groups B and C showed higher scores compared to groups A. Thus, students from mini-groups B, users of Vox Tools: Learn to Sing got the following scores: 80.8, 83.5, and 84.1, the average score being 82.8, which is 4.0% higher than the control group.

The mini groups C students who were users of the Swiftscales Vocal Trainer mobile app demonstrated scores of 82.8, 82.2, and 84.2, with an average score of 83.0, which is the highest of all groups, 4.2% above control. Analyzing these data, one can conclude about the effectiveness (which, however, is expressed weaker than in the case of second-year students) of mobile applications use in the context of vocal training. It is worth noting that fourth-year students performed better with Swiftscales Vocal Trainer, although the difference with Vox Tools: Learn to Sing was 0.2%, indicating that both applications demonstrated approximately the same effectiveness.

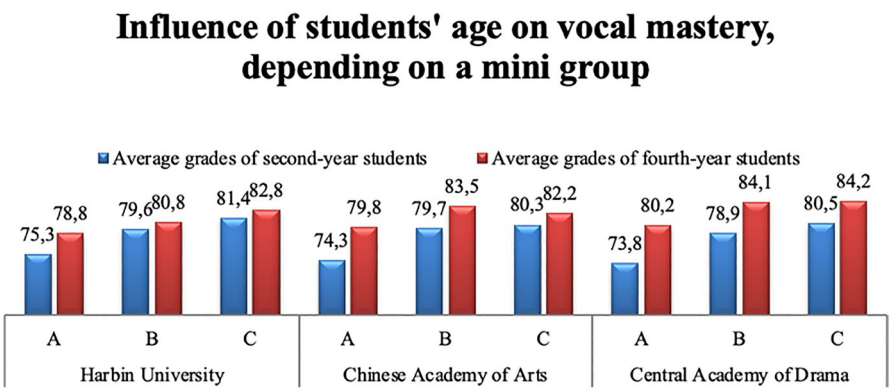

Fig. 3 Influence of students' age on vocal mastery, depending on a mini group

As for the peculiarities of performance in the context of studying vocal skills, depending on gender, according to the study results, male students of the fourth year showed higher results than male students of the second year, their performance in the criteria "work in class" and "modular control" was higher than that of female students of the fourth year. Thus, the average scores of male students were 81.9, while for female students this indicator was recorded at 81.7. The difference is absolutely insignificant and amounts to 0.2 points, from which one can conclude that with age the influence of gender on the process of vocal training decreases and does not play a significant role.

Objective 3 of the current study was to identify the impact of students' gender and age on the success of vocal training. Thus, comparing the overall performance in vocal lessons, one can conclude that the fourth-year students demonstrated a higher level of knowledge compared to their younger counterparts, representatives of the second year.

By analyzing the data presented in Fig. 3, it was found that the year of study had no effect on the educational process, regardless of whether a mobile app was used for vocal training: the performance of groups B and C is higher than A, regardless of the age of students. Age also showed no effect on either of the two available programs. Swiftscales Vocal Trainer in the entire sample showed higher values. The highest average scores were achieved by fourth-year students at Central Academy of Drama in groups B and C, 84.1 and 84.2, respectively. The lowest scores were demonstrated by second-year students at the same institution in Group A - 73.8. The probability of error of the obtained indicators is 0.1%.

5 Discussion

The first task of the study was to analyze the effectiveness of mobile applications in vocal training and track the effectiveness of mobile applications in comparison with the classical system without the use of special programs. This study found that control groups, which did not have access to mobile apps dedicated to singing practice, showed lower scores in their institutions. Other scholars have come to a similar conclusion. One study proved the usefulness of a conceptual model of synergy between technological and pedagogical solutions in developing vocal mastery. The model of introducing mobile applications in vocal training in accordance with the educational needs of the digital generation combines technological and pedagogical methods of teaching vocal and opens up opportunities for developing digital music education (Shi, 2021).

It was also important to determine which mobile app demonstrated greater effectiveness in vocal training, since the literature has previously reported that the effectiveness of similar programs differs from one another (Zidoun et al., 2019). Mobile apps offer training mostly based on visual and auditory tools, but with the potential to provide additional communication channels and styles of interaction with other users according to different contextual settings. In particular, common Internet-assisted learning systems can take advantage of sound communication to

augment educational programs as multichannel features become more common and give rise to new learning scenarios from which users can benefit. This suggestion finds support in similar research findings that suggest a number of learning scenarios that make it necessary or highly recommended to supplement classical learning with innovations (Sataloff, 2020; Zidoun et al., 2019).

Research in China supports the findings in this article: the combination of multimedia technology and computer-assisted instruction can better implement a vocal training program that is not limited to teaching only vocal skills but allows students to understand the true meaning of singing, seamlessly combine vocal and musical performance, and improve musical accompaniment. This educational practice allows students to achieve an artistic level of "sound and emotion" while performing (Yang, 2020). In addition, it would be helpful for a vocal teacher or music department to be able to accurately assess each student's vocal data and performance through objective measurements of vocal function.

Naturally, such high efficiency of mobile applications is not only the merit of the programs themselves, but also of high-quality classical training in educational institutions. Programs can improve it and give students more practice, but they cannot be a full-fledged substitute. Similar conclusions have been reached by other scholars, who believe that technological solutions will not replace traditional vocal instruction; rather, they will provide an additional set of tools to help identify specific problem areas and ensure sustained learning progress (Paule-Ruiz et al., 2013; Sataloff, 2020).

Multimedia technology in vocal training continues to evolve. Some research by Chinese scientists has focused on developing a visual learning simulator with real-time sound correction using the Python programming language and a library of classified reference audio files. The proposed methodology may be of practical value for pre-school educational institutions teaching music and other music schools and institutions (Zhang, 2021).

Also, one of the tasks of the article was to establish the influence of age and gender on vocal training success. According to the data obtained, the influence of gender has a close correlation with age in the context of vocal training. Thus, second-year male students demonstrated lower performance in all groups compared to female students. Gender plays a vital role in students' satisfaction with education, since differences in male and female attitudes toward innovative technology have previously been demonstrated in a number of studies (Arbaugh, 2014; Chang et al., 2014; González-Gómez et al., 2012). Researchers found that female students are more satisfied with e-learning subjects than male (González-Gómez et al., 2012). Male students' Internet self-efficacy has a stronger influence on their satisfaction with learning when assessing motivation (Chang et al., 2014). This information partially overlaps with the findings, but the current study found a leveling of the gender factor on student achievement, where age proved to be a significant factor.

In this way, the paper makes a theoretical contribution to existing research, confirming that the success of vocal learning can be influenced by modern mobile applications. The empirical contribution received in this study reveals an understanding of the impact of modern technology on music education in the

twenty-first century. Like the theoretical contribution, the empirical contribution demonstrates both originality and utility, and has implications for both research and practice. The practical value lies in the fact that mobile applications can be used in distance education and lead to improvements in the conduct of the educational process in the music industry. Also, this study has practical and scientific value because it demonstrates the impact of mobile apps in the context of vocal learning. Singing is not so much a merit of talent as of hard practice, so this article clearly demonstrates that through the use of additional multimedia, a higher and better result can be achieved. In addition, this paper sheds light on the impact of gender and age on vocal learning, which may be useful for further research on such topics.

5.1 Limitations

This study was conducted at three institutions of higher learning in China, so the results cannot reflect the impact of mobile vocal learning apps across the country. Besides, the study involved only two mobile apps, and there are many of them, which may impact their demonstrated effectiveness. Participants were randomly selected, and their overall performance was not taken into account when dividing them into groups. It is worth noting that although the evaluation criteria were uniform across the study, the evaluators varied from institution to institution. Also, the limitations in the experiment may be due to the lack of objectivity of teachers-instructors, the use of vocal education of students only two applications, the appeal to the updated teaching methods. The study did not involve the use of analysis of variance depending on the distribution of the variables (parametric or nonparametric tests), but Fisher's test was used to ensure the validity of the study.

6 Conclusions

Mobile applications make it possible to optimize the learning process, make it easier and more diverse. Online communication platforms and specialized applications help in the process of developing educational skills. Optimal technological solutions for improving and modernizing music education, whose functional features provide students with the opportunity to master listening skills by playing music games by ear, singing along to recordings in real time, listening and identifying chords, intervals, progressions, genres, etc.

The lowest scores were for mini groups A that received classical vocal instruction without the use of mobile apps at all three institutions: 75.3, 74.3, and 73.8, with an average of 74.5. On the contrary, mini groups B and C showed higher scores. Thus, students from mini groups B who were additionally users of Vox Tools: Learn to Sing got the following marks: 79.6, 79.7 and 78.9, the average score being 79.4, which is 6.5% higher than the control group. The mini groups C students who were users of the Swiftscales Vocal Trainer mobile app demonstrated scores of 81.4, 80.3,

and 80.5, with an average score of 80.7, which is the highest of all groups, and 8.3% above control.

These studies established the effectiveness of using mobile applications in the context of vocal training of students. Second- and fourth-year students performed better with the Swiftscales Vocal Trainer app, although the difference with the Vox Tools: Learn to Sing app was insignificant.

In the process of analysis, it was found that mobile applications were slightly less effective in the context of teaching vocal proficiency to fourth-year students than in the case of second-year students. As for the peculiarities of performance in the context of learning vocal skills, depending on gender, according to study results, fourth-year male students showed higher results than second-year ones, their performance in the criteria "work in class" and "modular control" was higher than that of fourth-year female students. Thus, the average scores of male students were 81.9, while for female students this indicator was recorded at 81.7. The difference is absolutely insignificant and amounts to 0.2 points, from which one can conclude that with age the influence of gender on the process of vocal training decreases and does not play a significant role.

It is worth noting that the findings might be applied in educational programs and research not only in China but around the world. An important aspect is the popularization of mobile apps to improve singing skills, demonstrating their relevance and suitability for further official inclusion in educational programs, because in a global sense the whole society is facing new challenges, for example, the pandemic, which has had a huge impact on the entire planet. In the context of distance education, specialized mobile apps in certain areas can be extremely useful. For future research, it is also important to examine the long-term effects of mobile apps on vocal learning, to pay attention to the limitations (limiting factors) presented in this article, and to continue research on this topic. For future research, differences among the three groups in vocal data and their criteria, or differences among the groups with regard to evaluation criteria, could be examined.

Authors' contribution All research processes was done by Yang Han.

Data availability Data will be available on request.

Declarations

Ethics approval The study was conducted in accordance with the ethical principles approved by the Ethics Committee of Harbin University.

Consent All participants gave their written informed consent.

Competing interests There are no competing interests to declare that are relevant to the content of this article.

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