Abstract
This study sought to evaluate the effectiveness of introducing digital software in music education to improve academic performance and solfeggio class attendance. To assess academic performance, a test consisting of 25 theoretical questions and 25 practical tasks was developed. The Bologna model was used as an assessment system. The groups were compared by calculating the Student’s t-test in terms of the “Test Score” and “Missed Classes” parameters. The collected data revealed that the mean score for the experimental group was 87.50 out of 100, while in the control group, it was much lower, namely 65.37. Likewise, the control group was characterized by satisfactory (D) performance in mastering solfeggio, with the mean score ranging between 64 and 73, whereas experimental group participants had an average of 82–89. The statistical data processing results showed that the six-month use of the ChordIQ app contributed to more effective mastering of solfeggio by amateur musicians. At the same time, the difference between the groups turned out to be significant in both cases, so the research hypothesis was confirmed for both of them (p<0.05). Overall, the results showed that ChordIQ is a useful mobile app teaching the user music in an exciting and interactive way. The findings collected can be used to update traditional solfeggio curricula, conduct scientific studies in the field of interactive music education, as well as create new dedicated software.

Keywords Aesthetic education · Educational motivation · Mobile learning · Mobile application · Music education · Solfeggio
1 Introduction

Along with literature, mathematics, history, and physical training, aesthetic education has become integral to many official curricula all over the world (D’olimpio, 2022). The sudden outbreak of the Covid-19 pandemic has shown that the educational sector is in high need of the development of innovative technologies and methodological approaches. Rather effective in this context appeared to be mobile applications providing an opportunity to optimize learning as well as attract students’ interest and boost their motivation and performance.

The aesthetic education of the past is marked by a pronounced emphasis on basic training and instrumental skills acquisition. However, today, more and more evident is the preference given to an integrated approach considering aesthetic education as a pedagogical environment for training, self-expression, creativity, and personal development (Amadio et al., 2006). The increased importance of the sociocultural factor in the modern educational process actualizes the issue of spiritual and aesthetic formation, which enhances the cognitive and mental potential of an individual (Kayumov, 2020). New teaching and learning models are mainly created by combining digital mobile technologies and traditional education schemes, which are characterized by vertical interaction and a clear distribution of social roles (Steinberg et al., 2020). Artistic and aesthetic development in the context of today’s learning activities is not a prioritized social task. Therefore, within general education, there is an acute shortage of facilities, equipment, and personnel (Muzyka et al., 2021). The use of art and digital technologies, in turn, makes it possible to activate the brain when recipients, for example, study musical intervals, notes, and harmonies (da Silva, 2020).

The aesthetic experience expansion contributes to the development of aesthetic intelligence, defined as the ability to comprehend, think, imagine and create based on acquired expertise, thereby stimulating the development of sensory memory and erudition development. Modern aesthetic education is not limited to the appreciation and creation of something beautiful as it can be expanded to a person’s desire for poetic cognition of the world and a comprehensive acquaintance with art and culture. In the international scientific discussion, aesthetic education is considered a means of environment preservation (Affifi, 2020). This is mainly dictated by the fact that any form of aesthetic education is aimed at developing love, empathy, and humility, as opposed to self-love and the philosophy of consumption. Today there is a need to expand what is meant by aesthetics and deepen the discussion about the role of aesthetic education in university curricula (Costa et al., 2021). Aesthetic experience and the ability to appreciate art are vital personality traits as they allow a person to express themselves and improve morally (D’olimpio, 2022). It is believed that aesthetic development generates a sense of autonomy and can also contribute to the creation of an alternative existential meaning, the development of critical thinking, and a focus on feelings (Lutfi, 2020). The relationship between self-education and aesthetic education growing out of the logic of Taoism as a philosophical doctrine is explored (Yan, 2021). It also is indicated that high-quality aesthetic education involves constant interaction with creative associations, unions, museums, philharmonic halls, theaters, music studios, galleries, exhibitions, photo galleries, public organizations, and libraries that ensure recipients’ personal development (Serykh, 2016).
In connection with the pandemic, mobile applications making aesthetic education interactive have gained much attention and popularity (Vorontsov, 2021). The central reason for this resides in the possibilities that such software provides for users in terms of illustrative materials and musical accompaniment creation, concert programs’ organization, and poster design. Precisely these capabilities make modern smartphones competitive with desktop computers or laptops while having only one disadvantage – screen width. The practice shows that mobile devices can be integrated into the local network of the educational institution by broadcasting the image to a larger screen in real-time to reduce the risk of vision loss among students. Furthermore, it is reasonable to use smartphones as a means of spiritual enrichment since a person gets an opportunity to devote their free time to aesthetic self-improvement and cultural horizons expansion (Zhang & Chen, 2017). This strategy allows combining family, school, and social aesthetic education, thus covering the key spheres of life of an individual (Zhang & Chen, 2017). At the same time, it must be said that the integration of the beforementioned digital technologies into extracurricular learning is highly dependent on the availability of mobile applications and technical means and has a predominantly stimulating effect (Mourgela & Pacurar, 2018; Ng, 2021).

One of the hypotheses of this research assumed that the use of mobile applications can improve aesthetic education quality and reduce school absenteeism (Cho et al., 2019). The relevance of such a study is explained by the fact that the modern school system purposefully strives to develop professional skills and accumulate knowledge while ignoring other aspects of the child’s personality associated with their feelings and thirst for immaterial knowledge. In view of its poor practical significance, aesthetic education devaluation leads to disharmony and inability to comprehend the national and universal experience. Effective integration of mobile applications into aesthetic education will resume the discussion about the importance of a person’s spiritual development and create additional opportunities for cultural education.

2 Literature review

In the study we presented scientific works, the analysis of which is given below in the section. The difficulty of studying aesthetic education as a full-fledged scientific category lies in the fact that this concept refers to many types of activity ranging from music to physical education. A systemic approach to aesthetic education starts with reflections on the interaction between sensory perception and bodily experience (Liebau, 2013). The digital age is causing some changes both in the cultural self-expression of young people and their traditional activities. For example, vlog videos and short video creation services (for example, TikTok) have become particularly widespread these days.

The prospect of using mobile apps in aesthetic education in formal and informal environments is currently the worst studied matter at the empirical level, which does not allow one to draw a reliable conclusion about the role these applications can play in practice (Rohde et al., 2019). It is noteworthy that some aesthetic education programs are based on the gaming principle, which assumes the presence of intrin-
sic motivation, self-control, and the acquisition of self-efficacy experience (Heyl & Schäfer, 2016).

In the predominance of cases, aesthetic education is described as a multifaceted and dynamic way of personal development that promotes creative and artistic components (Pater, 2016). However, it can be comprehended within the framework of aesthetics as a special form of scientific knowledge (Pater, 2016). Currently, no consensus has been achieved on this term interpretation. In German-speaking scientific circles, for example, the notion “aesthetic education” is used as a synonym for art and music education (Liebau, 2018). Creating access to art and artistic content is of tremendous importance for aesthetic reflection. However, there is a serious problem relating to the interaction with recipients who are forced to face artistic and aesthetic stimuli that are often accompanied by selective performance requirements. A study of the prospects of digital technology introduction in fine arts shows that it is generally a rare case – available works mainly focus on the formal learning process in accordance with the determination of the acquisition of professional competence, interest, and sustained motivation (Kröner et al., 2021). Modern pedagogical science postulates that every child should have an opportunity to develop their creative abilities and contemplate, compare, and evaluate everything that can be attributed to art (Denac, 2014). The development of the ability to notice the beauty around is the primary task of aesthetic education designed to evoke inspiration, joy, and optimism. These emotional states ennoble a person and encourage them to engage in art (Denac, 2014). In the digital age, aesthetic education is characterized by a variety of online learning resources. Thus, some researchers (Aufderheide, 2018; Maksł et al., 2015; Zhang, 2014) suggest shifting the focus to the formation of media literacy as an acquired cognitive ability to filter out information. By making art (dance, theater, fine art, music, poetry), a person voluntarily agrees to reveal their talent and face criticism that undermines self-esteem and promotes creative and artistic components (Uhrmacher, 2009).

Theoretical advances in e-learning show that the most successful online education examples involve a mixed activity format, including independent distance learning, co-education, online presentations, classroom presentations, and self-study (He, 2020; Koçoglu & Tekdal, 2020). Researchers agree that mixed activity format contributes greatly to the improvement in students’ academic performance, autonomy, consciousness, as well as academic motivation. In addition, it ensures students’ involvement in the learning process, discipline, and attendance (Yıldız & İsmail, 2016).

At a fundamental level, mobile applications are much more common in mastering core academic disciplines than aesthetic education, which is given relatively little attention (Drigas & Angelidakis, 2017). Nevertheless, there are successful examples of developed and implemented e-learning research projects on dramatic art (Baskerville, 2012). Ultimately, these projects were designed to involve learners in an e-learning environment. Their approbation allowed arguing that the high competence of recipients in the use of innovative information and communication technologies allows mobile applications and platforms to be used as intellectual influence tools (Niemi, 2003).
In sum, music education requires the formation and development of a broad number of musical skills and abilities. More precisely, these are an aesthetic taste for listening and perceiving music, ability to select a repertoire for performance on stage, acoustic characteristics (tone, tempo, hearing, and voice), ability to express and control emotions and feelings in the process of playing, musical instrument playing skills and many others (Fingerhut et al., 2021; Sala & Gobet, 2017).

2.1 Problem statement

The difficulty of studying aesthetic education as a categorical whole in the context of introducing electronic technologies has resulted from the fact that the former covers many types of activities, including singing, playing musical instruments, drawing, dancing, theatrical productions, and the study of cultural studies and art theory. Currently, there are no integrated applications combining interactive materials with heterogeneous content. This means that each sector should be considered separately. In line with this, it is agreed that the principles of classical mobile music learning applications fully coincide with the principles of aesthetic education (Han, 2022). First of all, this refers to voluntariness, independence, discipline, and self-efficacy, which are formed against the background of using mobile platforms of this kind.

The aim of this study was to assess the music applications’ impact on the quality of learning and class attendance in the framework of generally accepted extracurricular education. In this respect, the paper focuses on the study of solfeggio, which is considered one of the most difficult musical disciplines to be mastered (Lumbantoruan, 2020). The central research hypothesis was that it is possible to improve students’ abilities and form their readiness for independent learning not only by updating curricula but also by integrating mobile applications that provide the visibility and interactivity needed to learn solfeggio. The minor conjecture to be tested was that the use of mobile applications can reduce school absenteeism. For their reliable confirmation or rejection, the following tasks were to be accomplished: to form experimental and control groups in order to compare their academic achievement and attendance indicators; to develop identical and standardized evaluation criteria for comparing two groups of students studying solfeggio in traditional and interactive learning environments. The gap this research intended to bridge is related to the insufficient number of scientific works on the specifics of using mobile applications in aesthetic education.

3 Methods and materials

3.1 Instructional Design Model

3.1.1 Development

To analyze the effectiveness of the ChordIQ app in teaching students, this paper turns to the experimental and design approaches to developing the mobile app-based curriculum. The reliance on ChordIQ is explained by its potential to develop skills in singing or playing a variety of musical instruments, including guitar, piano, and
saxophone. While playing, users can learn notes, their meanings, key signatures, and intervals, as well as scales and chords. This helps memorize chords and scales in different keys. In addition, ChordIQ can be used to train one’s musical ear by learning notes, intervals, and chords. The developer claims that ChordIQ is a mobile-based music game focused on teaching the user in a fun and interactive way and gives the possibility to learn chords and scales using a MIDI keyboard connected to a phone or iPad device. The games provided by ChordIQ teach how to identify a key signature for bass and treble clef, major and minor scales; recognize a note on the staff with treble clef or bass clef; quickly determine what chord is displayed on-screen; learn to decide on whether the chord is major or minor promptly; learn major (minor) chord names and play them correctly on the keyboard or instrument. Also, the user is free to choose the scale to master: major, minor, or blues. Each game contains a virtual World Chart enabling one to track the progress among other ChordIQ players worldwide. ChordIQ interface is shown in Fig. 1.

It is important to mention that ChordIQ was selected solely for the research purpose; no material or non-material benefits were obtained from mentioning its name. The developer company has not made any attempts to fund this scientific research for the sake of promotion. Therefore, it is not a party of interest.

3.1.2 Implementation

The final test at the end of the six-month module consisted of 25 theoretical and 25 practical tasks asking research participants to determine the signatures for violin and bass keys, distinguish minor and major scales by ear, identify notes, and name and reproduce a chord. While the theoretical test part was taken by experimental and control groups together, the practical task was performed face-to-face with the teacher, who gave instructions and fixed students’ answers. As the evaluation model, a 100-point system widely used in Europe was selected. Hence, for each correct answer, 2 points were assigned. The grading was as follows: Excellent (A), Good (B, C), Satisfactory (D, E), Unsatisfactory with the Possibility of Re-Examination (F), Unsatisfactory with Mandatory Re-Examination (FX). It is important to mention here that the test fully reflected the material studied in the first module and was characterized by moderate complexity.

As a statistical means to check the equality of the mean values in the two samples, the Student’s t-test was used.
3.2 Participants

Research hypotheses testing required forming two groups of respondents: experimental and control. For the purity of experiment, the research sample included adults beginning to study music professionally, including solfeggio. The experimental and control groups included 30 amateur pianists aged 18–23 who willingly attended paid-for courses. Let us note that both samples were not representative from the biological sex perspective. For example, the experimental group consisted of 17 Chinese men and 13 women, and the control group consisted of 12 Chinese men and 18 women. However, we believe that the gender factor is not fundamental here. The two groups had different musical skill levels at the beginning of the study and pursued different goals when taking music courses. At the beginning of their studies, research participants had the opportunity to demonstrate their musical skills by playing a musical instrument. Educators supervising the experiment observed their play and recorded the assessed level of development of musical skills.

3.3 Design

The primary task of the study was to test the hypothesis that the interactive learning environment contributes to improving the quality of learning, namely, the study of solfeggio. This was supposed to be done in several stages. Stage 1 presupposed student training. The control group was trained according to the traditional approach, where the leading role was given to the teacher who taught solfeggio. The course equipment included a piano and a whiteboard to record basic information as well as visual materials to explain the theory. The teacher not only described theoretical aspects to learners but also taught them to recognize, name, distinguish, and reproduce the main notes, chords, and scales. The experimental group followed the same theoretical course but supported by ChordIQ games. Thus, during classes, the application was broadcast on a large-format TV screen, and each student had a Midi keyboard to practice. Both groups received similar homework, which was not checked by the teacher at the next lesson, but each student could seek advice in case of any questions. This was believed to increase the involvement of participants in the solfeggio learning process. Each experimental and control group participant had constant access to a musical instrument (a piano, synthesizer, or grand piano). At the same time, the experimental group also had an opportunity to use the app to ensure better assimilation of the educational material and perform unsupervised tasks. The groups were formed by random selection. None of the individuals who took part in the experiment had previously attended a music theory course or music classes. The frequency and duration of classes were the same – one-hour lesson once a week. Students’ personal progress in mastering solfeggio was compared at the end of the first half-year module.

During the second experiment stage, all students had to take a test reflecting their solfeggio competence. The academic achievement validity test was monitored by teachers who conducted the experiment and were present during the test. They observed the students playing musical instruments and recorded the results. None of the students were excluded from the study based on the test results; there was no
ranking and competitive system either. What is more, the control and experimental group leaders (teachers) did not exert any psychological pressure encouraging learners to study harder and devote more time to solfeggio. Each group had a teacher. The teachers exchanged the features of the lessons and the results obtained.

During the third stage, control and experimental groups were also compared by the number of classes their participants missed without a valid reason (a medical certificate). Of particular interest was the attendance as paid-for courses are usually assumed to contribute to high participation. None of the group leaders encouraged students to attend classes weekly. This stage sought to show whether personal interest was one of the main reasons for the regular solfeggio class attendance.

### 3.4 Evaluation

Statistical analysis was carried out in SPSS Statistics 23. Research instruments’ validation was done by means of the Student's t-test. Likewise, the Student’s t-test was used to determine the differences between the two independent samples by comparing mean values. Differences were considered statistically significant at $p<0.05$.

### 3.5 Ethical issues

From an ethical perspective, this research is characterized by neutrality as it does not raise ethnic, political, and personal identity issues. Its goals and objectives were comprehensively explained to the control and experimental groups after the testing procedure. The participants were told that the data would be averaged and generalized, and the research results are expected to improve the solfeggio teaching methodology. Verbal consent for further processing of test forms was received from each control and experimental group participant; none of them expressed their disagreement. However, it should be borne in mind that the two groups were formed following random selection. This means that the students were not allowed to independently choose between an interactive and a traditional learning environment, although they have paid the same amount of money for training. From an ethical perspective, this was an ambiguous step needed to ensure the experiment’s purity.

### 4 Results

During the first stage of the statistical analysis, students’ mean scores were compared. Quite notable was the fact that they varied significantly between the two groups constituting 87.50 out of 100 for the experimental group and 65.37 out of 100 for the control group. More details are given in Table 1.

|                      | N  | Mean | Standard deviation | Standard error |
|----------------------|----|------|--------------------|----------------|
| Solfeggio test score | Control group | 30  | 65.37              | 16.645         | 3.039          |
|                      | Experimental group | 30  | 87.50              | 7.152          | 1.306          |
Following the European Credit Transfer and Accumulation System, the control group is characterized by satisfactory (D) performance in mastering solfeggio, with the mean score ranging between 64 and 73 points. The experimental group scored higher with a B average (82 to 89 points). The Student’s t-test data are compared in Table 2.

As is shown by statistical data processing results, the six-month use of the ChordIQ app contributed to more effective mastering of solfeggio by amateur pianists in the experimental group. This evidence suggests that integrating an interactive learning environment into a music classroom positively affects student performance. There is no doubt that the result obtained can be explained by other reasons, which logically include teacher personality, the initial heterogeneity of the two groups, and the focus of the practical test section on games played by the experimental group. The similarity of conditions for mastering the educational material is also a controversial issue as the interactive environment created more opportunities for effective independent work, ensured visibility, and assumed the immediate consolidation of skills in recognizing notes, for example.

During the second research stage, the groups examined were compared by attendance. Here, the hypothesis that an interactive learning environment encourages students to attend classes regularly and not miss them without a weighty reason was tested. In doing so, only absences not justified by a medical certificate were taken into account. The proper level of interest and engagement in the learning process was ensured. The number of absences in each group was summed up for the six-month period and then compared using the Student’s t-test. Relevant data are presented in Table 3.

As is seen from the collected statistical processing outcomes, significant differences exist between the control and experimental groups since \( p < 0.05 \). On average, the students who used a mobile application to study missed six classes during the research period, whereas a slightly higher number of skipped classes (eight) was registered for the group taught following the traditional approach. Obviously, absence from classes is a private issue. The two groups consisted of more or less disciplined students. However, the statistics suggest a certain trend showing that an interactive learning environment can help reduce the number of classes missed. This is due to the immersion and interest that naturally arise in young people when they actively master a useful skill.

5 Discussion

Today’s academic society carries an ongoing discussion about the place of an interactive learning environment in aesthetic education as it is an exceptionally comprehensive interdisciplinary concept. It is currently safe to believe that the degree of mobile technology integration differs significantly depending on the field of activity, which can legitimately be attributed to aesthetic education. Available research on the matter suggests a number of solutions for developing and using mobile games for preschoolers’ aesthetic education (Paule-Ruiz et al., 2017). For example, the SAMI gaming platform for learning music draws on the Montessori method as a guide to the use of
| Solfeggio test score | t-criterion for equal means | Degree of freedom | Value (two-sided) | Mean difference | Mean squared error for the difference | 95% confidence interval for the difference |
|---------------------|-----------------------------|-------------------|-------------------|----------------|--------------------------------------|------------------------------------------|
|                     |                             |                   |                   |                |                                      |                                          |
|                     | Equal variances are assumed  | 58                | 0.000             | -22.133        | 3.308                                | -15.512                                 |                                          |
|                     | Equal variances are not assumed | 39.356          | 0.000             | -22.133        | 3.308                                | -15.445                                 | -28.754                                 |

Table 2: The impact of the interactive learning environment on solfeggio mastering
### Table 3 The impact of the interactive learning environment on solfeggio class attendance

|                      | t-criterion for equal means |                      | Standard mean error | 95% confidence interval for the difference |                      |
|----------------------|----------------------------|----------------------|---------------------|-------------------------------------------|----------------------|
|                      | Degree of freedom | Value (two-sided) | Mean difference |                      | Lower limit | Upper limit |
| Absences             | Equal variances are assumed | 58               | 0.000             | 2.800                         | 0.528         | 1.743       | 3.857       |
|                      | Equal variances are not assumed | 50.328 | 0.000             | 2.800                         | 0.528         | 1.739       | 3.861       |
various colors placed on a diatonic scale. Some mobile applications are entry-level e-learning platforms that serve as the first step for developing in the area further, for instance, Baby Mozart, Mazaam, Musical Me!, and Piano Maestro.

The use of mobile applications for educational purposes attracts a great deal of scholars’ attention. Its favorable effect on music students’ involvement receives considerable support from academic circles (Demirtaş & Özçelik, 2021). Similarly, researchers indicate that mobile applications can be effective in teaching a wide range of age groups. It is noteworthy that in a number of applications of this kind, there is a division into fundamental music theory, educational games, and practical use of musical instruments (Ng et al., 2013). This opens up opportunities for mastering solfeggio in both terms practical and theoretical and is important for maintaining high educational motivation ensured not only by the constant availability of the gadget but also by interactivity. The findings obtained by researchers in the field testify to the fact that music students express considerable interest in technological innovations and materials helping them prepare for solfeggio classes. These inferences partially confirm the tested hypothesis that mobile devices and applications are effective in unsupervised activities.

In Western Europe, creative software is actively used when solfeggio and instrument structure are touched upon at least partially, as the greatest potential is seen in their accompaniment (Ayhan & Ertekin, 2017). The empirical results obtained in this study are entirely consistent with researchers’ conclusions that traditional solfeggio learning methods presupposing no advantage taken of digital support cannot provide instant feedback on the correctness or incorrectness of the activity being performed. In concurrence with this, music software capabilities cannot be deemed an effective means for providing instructional material within distance learning. It was proved that despite the extensive use of interactive techniques, the academic performance of groups that studied remotely was lower than that of those students who studied in class (Bond, 2002).

In a study conducted to evaluate the effectiveness of the Auralbook app in teaching auditory skills, it is claimed that the users showed significant progress in stylistic recognition of sounds at the initial level and in singing at the intermediate level (Chen, 2015). It was confirmed that digital learning improves students’ academic performance and has a positive effect on their motivation. In the same way, an analysis of the process of studying solfeggio with the help of computer technology concluded that learning music with the help of information and communication technologies turned out to be more enjoyable and effective compared to the traditional approach (Kiraly, 2003).

Researchers indicate that the mySolfeggio app, which has many common features with ChordIQ, contributes to an increase in the academic success of primary school children in musical intervals and rhythmic accuracy compared to the control group taught under conventional instruction (Debevc et al., 2020). In the same vein, the PracticeCactus app teenage musicians used for 20 weeks to enhance their piano skills benefited not only instrument mastery but also social interaction in the context of independent play. In this case, the children were given an opportunity to share their achievements with peers and listen to the experiences of others (Birch, 2018).
Interactive learning environment study has also recently been carried out on the example of stringed instruments. In this manner, researchers strived to test the effectiveness of the Yousician mobile app, ultimately designed to facilitate guitar playing techniques learning. Despite the high prospects, the outcomes of that research are based on the use of the program for one week and the sample consisting of four people only, which does not give the right to consider the empirical data obtained reliable (Yun & Thiruvarul, 2021).

An interactive learning environment as a motivational factor was mainly studied through surveys and interviews of people who constantly use applications to study music. Such works indicate that implementing information and communication technologies can expand the boundaries of learning music in the classroom and open up many new and exciting opportunities. These include students’ technical literacy improvement and ensuring the diversity of the learning environment in which computer communications are used. It is these factors that encourage students to attend classes and remain highly interested (Ho, 2007).

In general, the traditional format of studying solfeggio is often monotonous, which is the key cause for the avoidance strategy application on the part of learners. It is not infrequent nowadays when, seeking new ways to teach music, scholars resort to educational games combining VR elements in genres such as horror and shooter (Yang & Cheng, 2020). The validated effectiveness of such learning means fully confirms our hypothesis that the creation of an interactive learning environment has a positive effect on learning motivation, which was considered within this research as class attendance.

6 Conclusion

This theoretical and empirical research revealed that music education as part of aesthetic education can be notably improved by integrating interactive components. First of all, this refers to mobile applications that help train musicians due to emphasized visualization, inform them about the correctness of tasks, and give them the opportunity to track their progress.

The control and experimental groups sampled for this study consisted of 30 people each (age range 18–23) who were interested in music but had never studied it before. The scientific research object was represented by the discipline of solfeggio as it is considered a fundamental theoretical discipline that pianists begin to master at the very beginning of their studies. In total, the research process presupposed 26 solfeggio classes to be held, after which all students received homework but were the only ones responsible for its performance quality. The size of subgroups engaged in solfeggio learning was ten people each. The duration and frequency of classes were the same for everyone – one hour, once a week.

In sum, the carried-out analysis allowed concluding that a six-month use of the ChordIQ application improved academic performance in solfeggio. Moreover, in the experimental group, attendance was also much higher than that in the control group, which learned the same material in a traditional way. Hence, in the course of the study, both hypotheses set were confirmed.
The practical value of the research lies in the fact that the effectiveness of the digital technology introduction in music education was confirmed. This can accelerate the integration of helpful software into the study of solfeggio among children and young people in order to facilitate the assimilation of educational material and maintain their high personal interest throughout the course. The scientific value of the study resides in the revival of the global discussion about the importance of aesthetic education for spiritual development, self-expression, and creativity. Deep understanding of the cultural experience of previous generations is as critical as self-realization, career growth, and professional development.

The results obtained can be taken advantage of when developing educational programs in the field of solfeggio, music theory, and keyboard musical instruments playing. Also, they might be useful for those willing to improve musical skills on their own. Further research should focus on the effectiveness of the ChordIQ application in the study of solfeggio by guitarists, saxophonists, and cellists, as the software is multifunctional.

6.1 Limitations

As almost any academic research in the field, this study had a number of limitations. Firstly, the test designed to assess the mastery of the educational material is not standardized. Secondly, the research participants attended private music courses, which might have affected not only their motivation to learn but also their general interest in mastering the discipline. Thirdly, each experimental and control group member voluntarily decided to master music at a more professional level, which cannot be compared with those situations where the recipient begins to study solfeggio at primary school age. Fourthly, skipping classes could be associated with an objective lack of time and an urgent need to solve other life issues rather than with a loss of interest. Fifthly, we had not studied the levels of musical hearing and memory in those who eventually joined the experimental and control groups, even though these differences were found at the individual level and were associated not only with skill but also with innate abilities. Sixthly, the ChordIQ application is positioned as a means of interactive learning for the pianists in the samples and guitarists, for example. This is attributed to limiting factors as one of the instruments is a keyboard, and the other one is a string, which may be important when mastering solfeggio. The age factor can also be considered limiting since the study covered only one age group.

Authors’ contributions MO is the sole author of the manuscript and fully responsible for the experimentation, writing and editing the article, design and literature studying about the topic. MO read and approved the final manuscript.

Funding This research was supported by Hunan Vocational College Education and Teaching Reform Research Higher Vocational Education General Project (ZJGB2021267), and Open Fund of Cooperative Innovation Center for Digitalization of Cultural Heritage in Traditional Villages and Towns in Hunan Province (GC19K02).

Data Availability Data will be available on request.
Declarations

Conflict of interest This research has no conflict of interests.

Ethics approval The author declares that the work is written with due consideration of ethical standards. The study was conducted in accordance with the ethical principles approved by the Ethics Committee of YongZhou Vocational Technical College.

Consent to participate Informed consent was signed by participants.

Consent for publication Not applicable.

References

Affifi, R. (2020). Beauty in the darkness: Aesthetic education in the ecological crisis. *Journal of Philosophy of Education*, 54(4), 1126–1138. https://doi.org/10.1111/1467-9752.12475

Amadio, M., Truong, N., & Tschurenev, J. (2006). *Instructional time and the place of aesthetic education in school curricula at the beginning of the twenty-first century*. UNESCO International Bureau of Education

Aufderheide, P. (2018). Media literacy: From a report of the national leadership conference on media literacy. In *Media literacy in the information age* (pp. 79–86). Routledge

Ayhan, A., & Ertekin, B. (2017). An evaluation on solfeggio training studies through notation videos: An example of musicolage. In A. Bakla, H. Demiröz, & A. Çekiç (Eds.), *Uluslararası Eğitim Teknolojileri Sempozyumu* (pp. 25–38). Cumhuriyet University

Baskerville, D. (2012). Integrating on-line technology into teaching activities to enhance student and teacher learning in a New Zealand primary school. *Technology Pedagogy and Education*, 21(1), 119–135. https://doi.org/10.1080/1475939X.2012.659887

Birch, H. J. S. (2018). *Music learning in an online affinity space: Using a mobile application to create interactions during independent musical instrument practice*. Doctoral dissertation, University of Toronto (Canada)

Bond, A. (2002). *Learning music online an accessible learning program for isolated students*. Australian National Training Authority

Chen, C. W. J. (2015). Mobile learning: Using application Auralbook to learn aural skills. *International Journal of Music Education*, 33(2), 244–259. https://doi.org/10.1177%2F0255761414533308

Cho, S., Baek, Y., & Choe, E. J. (2019). A strategic approach to music listening with a mobile app for high school students. *International Journal of Music Education*, 37(1), 132–141. https://doi.org/10.1177/0255761418819016

Costa, H., Stoltz, T., & da Silva, T. F. B. X. (2021). Relationship between aesthetics, education and design: The aesthetic education. *Atos de Pesquisa em Educação*, 15(1), 1185–1204

D’olimpio, L. (2022). Defending aesthetic education. *British Journal of Educational Studies*, 70(3), 263–279. https://doi.org/10.1080/00071005.2021.1960267

da Silva, R. S. R. (2020). On music production in mathematics teacher education as an aesthetic experience. *Zdm Mathematics Education*, 52(5), 973–987. https://doi.org/10.1007/s11858-019-01107-y

Debeve, M., Weiss, J., Sorgo, A., & Kožuh, I. (2020). Solfeggio learning and the influence of a mobile application based on visual, auditory and tactile modalities. *British Journal of Educational Technology*, 51(1), 177–193. https://doi.org/10.1111/bjet.12792

Demirtaş, E., & Özçelik, S. (2021). Music students’ use of mobile applications for learning purposes. *International Journal of Modern Education Studies*, 3(2), 299–325. https://doi.org/10.51383/ijomes.2021.135

Denac, O. (2014). The significance and role of aesthetic education in schooling. *Creative Education*, 5(19), 51211. https://doi.org/10.4236/ce.2014.519190

Drigas, A. S., & Angelidakis, P. (2017). Mobile applications within education: An overview of application paradigms in specific categories. *International Journal of Interactive Mobile Technologies*, 11(4), 17–29. https://doi.org/10.3991/ijim.v11i4.6589
Fingerhut, J., Gomez-Lavin, J., Winklmayr, C., & Prinz, J. J. (2021). The aesthetic self: the importance of aesthetic taste in music and art for our perceived identity. *Frontiers in Psychology, 11*, 577703. https://doi.org/10.3389/fpsyg.2020.577703

Han, Y. (2022). Using mobile applications in the study of vocal skills. *Education and Information Technologies*, in press. https://doi.org/10.1007/s10639-022-11268-1

He, J. (2020). Construction of “three-stage asynchronous” instructional mode of blended flipped classroom based on mobile learning platform. *Education and Information Technologies, 25*(6), 4915–4936. https://doi.org/10.1007/s10639-020-10200-9

Heyl, T., & Schäfer, L. (2016). *Frühe ästhetische Bildung–mit Kindern künstlerische Wege entdecken*. Springer. https://doi.org/10.1007/978-3-662-48105-9

Ho, W. C. (2007). Students’ experiences with and preferences for using information technology in music learning in Shanghai’s secondary schools. *British Journal of Educational Technology, 38*(4), 699–714. https://doi.org/10.1111/j.1467-8535.2006.00643.x

Kayumov, A. V. (2020). System-technological approach to spiritual and aesthetic education in the study of pedagogical disciplines. *European Journal of Research and Reflection in Educational Sciences, 8*(3), 112–144

Kiraly, Z. (2003). Solfeggio 1: A vertical ear training instruction assisted by the computer. *International Journal of Music Education, 1*, 41–58. https://doi.org/10.1177%2F025576140304000105

Koçoglu, E., & Tekdal, D. (2020). Analysis of distance education activities conducted during COVID-19 pandemic. *Education and Research Reviews, 15*(9), 536–543. https://doi.org/10.5897/ERR2020.4033

Kröner, S., Christ, A., & Penthin, M. (2021). Stichwort: Digitalisierung in der kulturell-ästhetischen Bildung–eine konfigurierende Forschungssynthese. *Zeitschrift für Erziehungswissenschaft, 24*(1), 9–39. https://doi.org/10.1007/s11618-021-00989-7

Liebau, E. (2013). Ästhetische bildung: Eine systematische annäherung. *Zeitschrift für Erziehungswissenschaft, 16*(3), 27–41. https://doi.org/10.1007/s11618-013-0433-x

Liebau, E. (2018). Kulturelle und ästhetische bildung. *Handbuch Bildungsforschung* (pp. 1219–1239). Springer VS. https://doi.org/10.1007/978-3-531-19981-8_54

Lumbantoruan, J. (2020). Developing song reproduction drill to improve solfeggio learning achievement. In *Conference Series* (Vol. 2, No. 1, pp. 145–153), ADI

Lutfi, D. A. M. (2020). Art and aesthetic education. *Journal of Research in Philosophy and History, 3*(1), 19–26. https://doi.org/10.22158/jrph.v3n1p19

Maksla, A., Ashley, S., & Craft, S. (2015). Measuring news media literacy. *Journal of Media Literacy Education, 6*(3), 29–45. https://doi.org/10.23860/jmle-6-3-3

Mourgela, V., & Pacurar, E. (2018). Children, extracurricular activities, and digital media: The process of displacement and school performance. *Journal of Educational Computing Research, 52*(6), 202–225. https://doi.org/10.1177%2F0255761417707792

Muzyka, O., Lopatiuk, Y., Belinska, T., Belozerskaya, A., & Shvets, I. (2021). Modern aesthetic education and its further directions. *Linguistics and Culture Review, 5*(S4), 12–21. https://doi.org/10.21744/lingcure.v5nS4.1537

Ng, S. C., Lui, A. K., & Lo, W. S. (2013). An interactive mobile application for learning music effectively. In *International Conference on ICT in Teaching and Learning* (pp. 148–157). Springer. https://doi.org/10.1007/978-3-642-45272-7_14

Ng, T. K. (2021). New interpretation of extracurricular activities via social networking sites: A case study of artificial intelligence learning at a secondary school in Hong Kong. *Journal of Education and Training Studies, 9*(1), 49–60. https://doi.org/10.11114/jets.v9i1.5105

Niemi, H. (2003). Towards a learning society in Finland: Information and communications technology in teacher education. *Technology Pedagogy and Education, 12*(1), 85–103. https://doi.org/10.1080/14759390300200147

Pater, R. (2016). Edukacja estetyczna w permanentnym rozwoju osobowości. Działania edukacyjne muzeów i centrów nauki. Rocznik Naukowy Kujawsko-Pomorskiej Szkoły Wyższej w Bydgoszczy Transdyscyplinarne Studia o Kulturze (i) Edukacji, 11, 290–307

Pauel-Ruiz, M., Álvarez-Garcia, V., Pérez-Pérez, J. R., Álvarez-Sierra, M., & Trespalacios-Menéndez, F. (2017). Music learning in preschool with mobile devices. *Behaviour & Information Technology, 36*(1), 95–111. https://doi.org/10.1080/0144929X.2016.1198421

Rohde, J., Jäkel, H., Pfeifer, V., Züchner, I., & Thole, W. (2019). Kulturell-ästhetische kinder-und jugendbildung und digitalisierung. *Soziale Passagen, 11*(2), 369–374. https://doi.org/10.1007/s12592-019-00331-3
Sala, G., & Gobet, F. (2017). When the music’s over. Does music skill transfer to children’s and young adolescents’ cognitive and academic skills? A meta-analysis. Educational Research Review, 20, 55–67. https://doi.org/10.1016/j.edurev.2016.11.005

Serykh, L. V. (2016). Methodological bases of interaction of general educational and out of school educational institutions in aesthetic education of schoolchildren. World Science, 5(10.14), 30–34

Steinberg, C., Zühlke, M., Bindel, T., & Jenett, F. (2020). Aesthetic education revised: A contribution to mobile learning in physical education. German Journal of Exercise and Sport Research, 50(1), 92–101. https://doi.org/10.1007/s12662-019-00627-9

Uhlmacher, P. B. (2009). Toward a theory of aesthetic learning experiences. Curriculum Inquiry, 39(5), 613–636. https://doi.org/10.1111/j.1467-873X.2009.00462.x

Vorontsov, С. О. (2021). Mobile devices in teaching information technologies at institutions of higher art education. Information Technologies and Learning Tools, 83(3), 100–112. https://doi.org/10.33407/itlt.v83i3.3684

Yan, Y. (2021). Laozi’s aesthetic education philosophy on self-education. Journal of Contemporary Educational Research, 5(8), 225–228. https://doi.org/10.26689/jcer.v5i8.2484

Yang, J. S., & Cheng, C. W. (2020). A pitch perception training game in VR environment for enhancing music learning motivation. In 2020 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-Taiwan) (pp. 1–2). IEEE. https://doi.org/10.1109/ICCE-Taiwan49838.2020.9257989

Yildiz, E. P., & Isman, A. (2016). Quality content in distance education. Universal Journal of Educational Research, 4(12), 2857–2862. https://doi.org/10.13189/ujer.2016.041220

Yun, Y. T., & Thiruvarul, S. (2021). Understanding the potential of music learning application as a tool for learning and practicing musical skills. International Journal of Creative Multimedia, 2(1), 42–56. https://doi.org/10.33093/ijcm.2021.2.1.3

Zhang, B. (2014). The college aesthetic education teaching and students’ psychological mechanism development in network age. In International Conference on Education, Language, Art and Intercultural Communication (ICELAIC-14) (pp. 232–235). Atlantis Press. https://doi.org/10.2991/icelaic-14.2014.59

Zhang, J., & Chen, B. (2017). Study of mobile aesthetic education: A perspective of internet plus. Journal of East China Normal University, 35(5), 109–116. https://doi.org/10.16382/j.cnki.1000-5560.2017.05.009

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.