AI in Music Education: The Impact of Using Artificial Intelligence (AI) Application to Practise Scales and Arpeggios in a Virtual Learning Environment

Chapter · December 2020

DOI: 10.1007/978-981-15-8167-0_19

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AI in Music Education: The Impact of Using Artificial Intelligence (AI) Application to Practise Scales and Arpeggios in a Virtual Learning Environment

Jason Chi Wai Chen

Abstract This pilot study investigates the impact of using mobile devices to facilitate the practising of scales and arpeggios. The AI application was designed by an engineer/musician in Hong Kong. This AI application enables students to practise, record themselves, view their mistakes and prepare for examinations based on the Associated Board of the Royal Schools of Music's scales and arpeggios syllabus for five instruments (violin, flute, clarinet, trumpet and saxophone). This study (a) examines the progress of learners who use the application to practise scales and arpeggios; (b) observes how elementary learners perceive mobile practising in a virtual learning environment and (c) proposes a blended learning model that uses mobile practising with the support of AI.

Keywords Mobile practising · Scales and arpeggios · Artificial intelligence · Scalebook · Virtual learning environment

1 Introduction

The purpose of this study is to evaluate the impact of using AI in practising music. Learning progress was observed through the database of the application to see whether the frequency of user logins to the program and achievements in scale learning were correlated. Issues such as self-regulated practice, self-efficacy and musical memory were addressed through a survey of the users. The blended learning of scales and arpeggios was studied through teacher interviews. This study asks how this AI application can solve issues in classroom and studio pedagogy such as time limitations and the monitoring of practice. For consistency, the term AI application is adopted in this study. This AI application was designed and trademarked in 2017 and has already been launched for users in the UK, the US, Australia and Hong Kong. The designer has agreed to support the process of data collection through online

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W. W. K. Ma et al. (eds.), *Learning Environment and Design*,
Educational Communications and Technology Yearbook,
https://doi.org/10.1007/978-981-15-8167-0_19

surveys and file analysis. The author declares that no conflict of interest is involved in this study.

The following research questions have guided the present study:

1. Is AI application an effective tool for practising scales and arpeggios?
2. To what extent does AI application enhance mobile practising?
3. How can mobile practising be implemented in studio teaching?

2 Literature

2.1 Learning Through Mobile Devices

Today, we are surrounded by rapidly developing technology. Rossing, Miller, Cecil and Stamper (2012) claimed that changes in technology continue to alter possibilities for learning and create new challenges for pedagogy. One new trend is learning through mobile devices, like tablets, at school and at home. A research team from Indianapolis defined mobile learning as the efficient and effective use of wireless and digital devices and technologies to enhance learners' individual outcomes during participation in learning activities.

Mobile devices act as a platform for students to learn and study at any time and in any place. Melhuish and Falloon (2010) stated that in many ways mobile technologies have the capacity to stimulate a redefinition of what constitutes a learning space, away from the constraints of a fixed place and time, towards a conceptualisation based on connecting people with each other and information, through virtual collaborative spaces and communities which are highly fluid, and not bounded by time or location. Chen (2015) studied the use of e-Auralbook to facilitate a mobile learning environment for teachers and students in both school and studio settings. This study extends this line of research by studying how mobile practising can be used by instrument teachers and learners to master scales and arpeggios.

The Horizon Report (Johnson, Levine, Smith, & Stone, 2010) reported that the iPad tablet is suitable for use in fieldwork due to its portability and usefulness for document and e-book transportation, real-time observation recording and reference evaluations.

2.2 Scale Learning

Scales are an essential element of basic technique. Franke (2013) explained that the primary purpose of scale and arpeggio practice is to develop and enforce the ability to stay within a given key or harmony. Scale learning is one of the requirements for playing an instrument, especially an orchestral instrument.

2.3 Artificial Intelligence (AI)

According to Warwick (2012), the field of Artificial Intelligence (AI) really came into existence with the birth of computers in and around the 1940s and 1950s. In the early period of AI's development, scientists focused on getting computers to do things that, if a human did them, would be regarded as intelligent. Essentially, this involved trying to get computers to copy humans in some or all aspects of their behaviour, an approach referred to as classical AI. The AI application as a form of classical AI, acts as a home teacher that simulates private instrument lessons. The AI application provides instant feedback after recording students' performance. Johnson (2014) suggested that real-time feedback has great potential for enhancing learning complex motor skills by enabling people to correct their mistakes as they go.

In addition, the AI application displays the two-dimensional score of students playing with an automatic music transcription (AMT) technique. Automatic music transcription is the process of converting an acoustic musical signal into some form of musical notation. Benetos, Dixon, Giannoulis, Kirchhoff, and Klapuri (2013) defined AMT as the process of converting an audio recording into a piano-roll notation—a two-dimensional representation of musical notes across time—and defined as the process of converting a recording into common music notation.

According to Conati, Porayska-Pomsta, and Mavrikis (2018) advocated that AI in education needs interpretable machine learning as lessons from open learner modelling. They investigated how to leverage AI techniques formally known as Intelligent Tutoring System (ITS) in the 1970s to create educational technologies that are personalised to the needs of the individual learners with the goal to approximate the well-known benefits to one-to-one instruction. The idea is to build intelligent interactive tutors that can model, predict and monitor relevant learner behaviours, abilities, and mental states in a variety of educational activities and provide personalised help and feedback accordingly. In this study, the AI application functions as an ITS with AI to analyse, improve, predict and monitor the learning process of practising scales with a Personal Tutoring System (PTS).

2.4 Virtual Learning Environment

Based on the sources from the AI application *Scalebook*, it was designed to use mobile devices to enhance scale and arpeggio practice for elementary learners of orchestral instruments. The AI application is based on the Grade 1–Grade 5 scales and arpeggios syllabus of the Associated Board of the Royal Schools of Music (ABRSM). The AI application provides a platform for elementary orchestral players to practise scales and arpeggios and acts as a tool that allows teachers to monitor and improve students' practice after each private lesson, as shown in Fig. 1. The AI application includes basic functions such as tuners and metronomes. It comes in three languages: English, Cantonese and Mandarin.

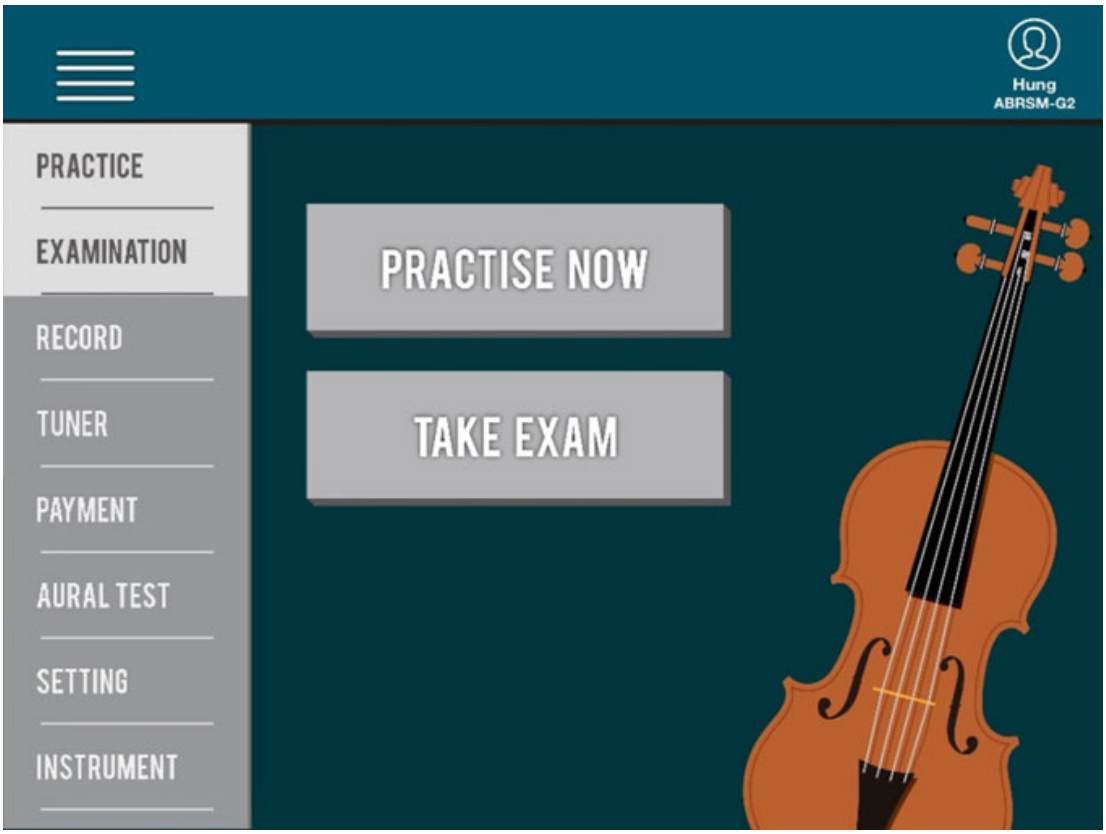


Fig. 1 Core functions in the AI music application

The AI application provides two platforms: *practice mode* and *examination mode.*

Practice mode is designed for students to practise scales and arpeggios at home. It contains two ways to select the scales or arpeggios: *recommended* and *personalised*. The score is displayed on the screen with a key signature. Students can slide their fingers along the notes in the score to view the suggested fingerings and positions in the selected scale or arpeggio. The tempo can be adjusted by pressing the arrows next to the tempo marking, as shown in Fig. 2. Students are asked to play the scales and arpeggios following the beats of the metronome. The AI application analyses the student's practice session and indicates errors in intonation, rhythm and sliding notes with comments and red circles. Students may press the red circles on the score to explore their specific errors. They may also click the demo button to listen to a demonstration of correct playing, or press the playback button to hear their own playing.

Examination mode is a platform for rehearsing before attempting the real ABRSM Grade 1–Grade 5 scales and arpeggios examination, shown in Fig. 3. Scales and arpeggios from the same grade are randomly selected to test the student. A standard marking sheet is displayed with comments in Fig. 4. Stars are used to indicate the accuracy of the student's playing. The marking sheet is stored as a record in the AI application.

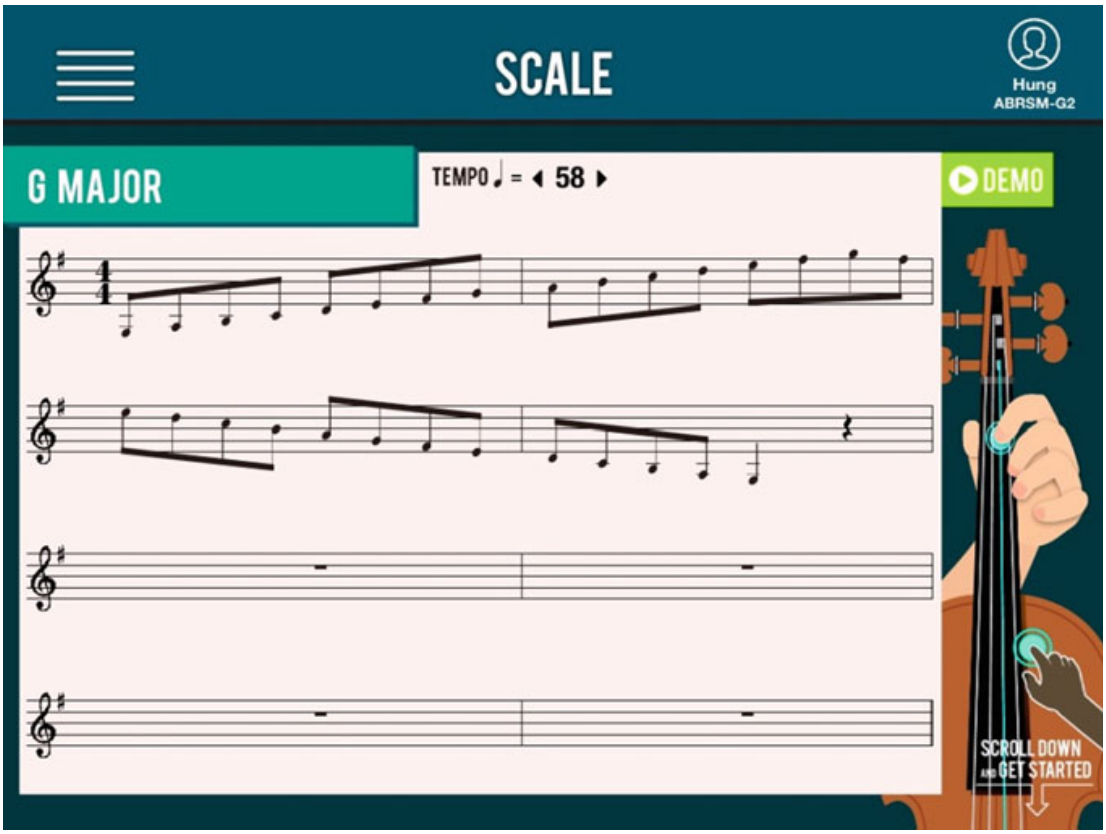


Fig. 2 Scores with the fingering board in practice mode

3 Methodology

3.1 Data Sources

In this study, data were collected from three sources: (1) an online survey, (2) file analysis and (3) individual interviews with studio teachers.

3.1.1 Online Survey

Table 1 shows the online survey conducted to learn about the interests and motivations of the AI music application users. In this pilot study, 24 users (n = 24) from around the world were invited to practise scales and arpeggios on five orchestral instruments (violin, flute, clarinet, saxophone and trumpet) over 8 weeks. After 8 weeks of practice, an evaluation questionnaire with seven questions on a 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) was sent to the application users to study how they used it and their perceptions of their self-regulated learning, musical memory and self-efficacy.

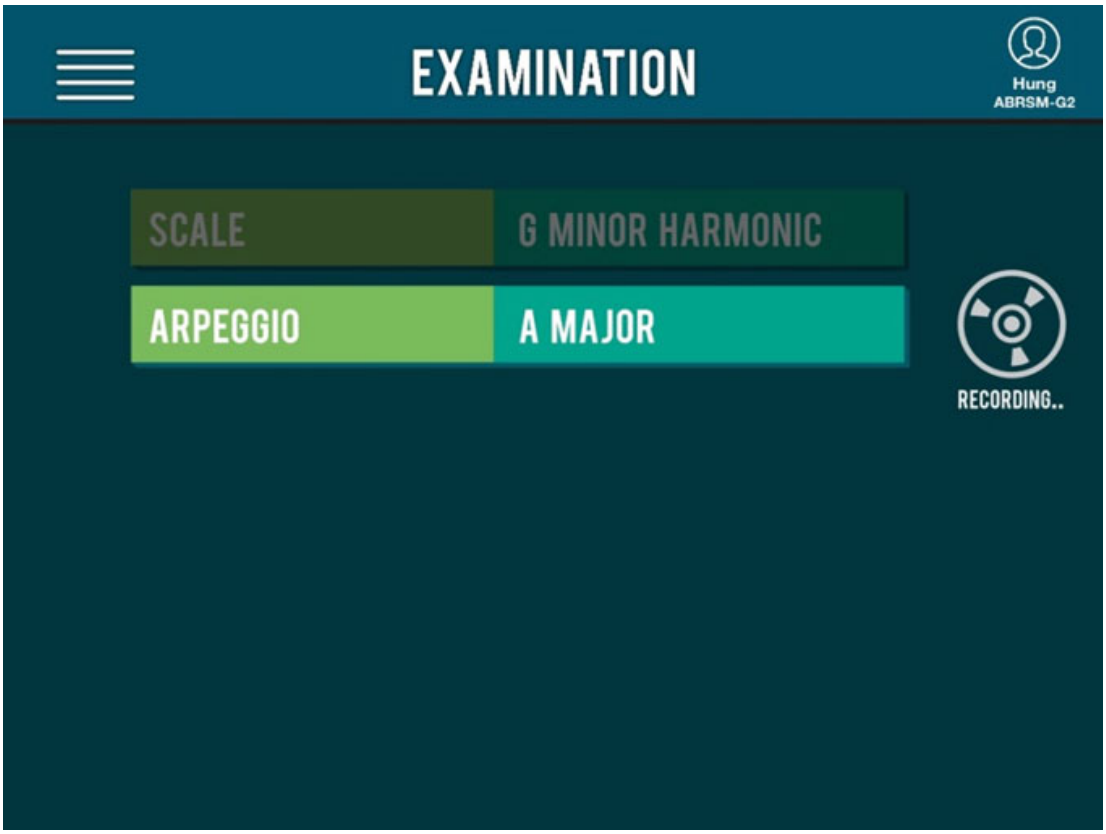


Fig. 3 Exam mode page

3.1.2 File Analysis

An analysis of data files was retrieved from the AI application database. The sample size (n = 24) was 24 valid frequent users. Data were retrieved for beginners (ABRSM Grades 1–5) only. All participants received unlimited access to the AI application. They were asked to practise scales and arpeggios with the AI application for 8 weeks. Specifically, they practised a scale or an arpeggio from the ABRSM exam syllabus (Grade 1–Grade 5) using the AI application at least three times a week. All of their practice records were saved in cloud storage. After 8 weeks of practice, data were retrieved to verify their practice habits. Students' mean scores were calculated based on the starting and ending mean scores and how these scores impact students' music practice.

3.1.3 Individual Interviews

Semi-structured individual interviews with studio teachers were conducted. Five instrument teachers were interviewed with the following questions to understand how they used the application with daily instrument lessons and what they thought of it as a mobile practising device.

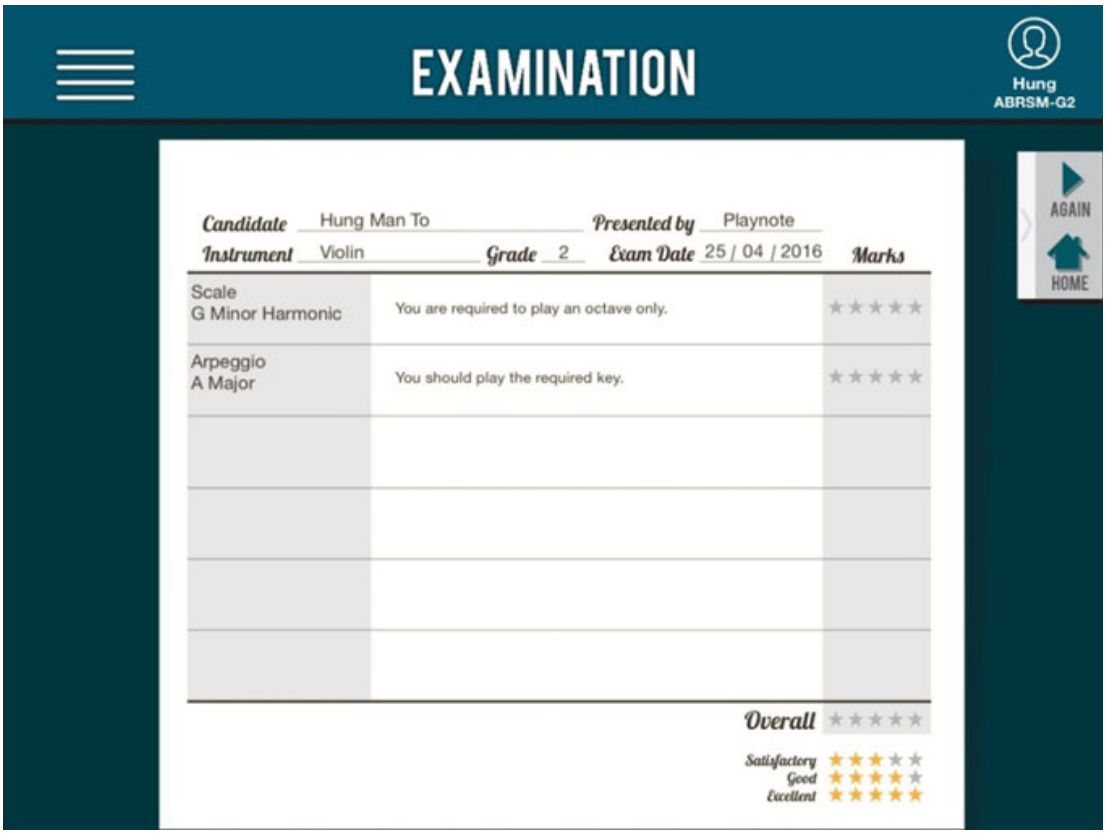


Fig. 4 Standard mark sheet in examination mode

Table 1 Online survey questions

Q1 Using the AI application to practise scales can enhance my learning
Q2 Using the AI application to practise scales can enhance my performance
Q3 Using the AI application to practise scales can regulate my practising habits
Q4 The AI application can enhance my musical memory (e.g., notes, sharps and flats)
Q5 The AI application can enhance my confidence in playing scales and arpeggios
Q6 The AI application can improve my motor skills (e.g., fingerings and muscle memory)
Q7 Any suggestions/comments (open-ended)

1. How did you find the motivation of the students after they started to use the AI music application?
2. Did you find the application enhanced your students' musical skills?
3. Do you think the 'blended learning' mode (face-to-face plus mobile learning) is effective in teaching scales and arpeggios?

4. Would you continue to use this blended learning approach in the future? Why or why not?

3.2 Triangulation

A triangulation of these three data sources—user surveys, file analysis and teacher interviews—formed a proposed model for using AI application to support mobile practising of scales and arpeggios. In this study, both quantitative and qualitative data were collected. The results of the study were derived in three stages. The first stage provided an overview of mobile practising through an online survey. The second stage involved observing learning progress through file analysis of the starting and ending mean scores. In the third stage, views, feedback and insights were collected from in-service instrument teachers who were currently using the application in their daily teaching practice. The study went from the macro level to the micro level to integrate a broad perspective with in-depth understanding.

3.3 Sample Selection and Validity

Only frequent users who had fulfilled the basic practice requirements were counted as valid users. The relationship between the frequency of use of the application over the period of 2 months and the practice scores were analysed.

3.4 Data Analysis

The data analysis focused on the differences between the starting and ending mean scores of the valid frequent users. The starting and ending means were calculated by finding the average of the records between 1 December 2018 and 31 January 2019. The following cases were considered invalid records:

1. The recording was not all done by the same person;
2. Two or more people were practising at the same time;
3. No practices were offered in the record;
4. The user was doing something other than answering the questions; and
5. The recording was disturbed by the environment.

The remaining records were considered valid records for this study's purposes.

For the first and second data sources, all volunteers had to tick 'agree' to participate in this pilot study for 2 months through an online agreement. For the third data source, the individual interviews, consent forms were signed by the human subjects when the qualitative data were collected. The researcher declares that there is no conflict

of interest in this research between the application company and the researcher. No commercial agreements or benefits were derived from this study.

4 Results

4.1 Online Survey

4.1.1 Geographical Distribution of the Respondents

Twenty-four respondents replied to this survey. The majority came from the UK (38%) and Hong Kong (34%), followed by Australia (8%), Spain (8%), Singapore (4%), Malaysia (4%) and Malta (4%). This geographical distribution maintains the reliability of this research as a globalised study. Figure 5 shows the geographical distribution of the respondents.

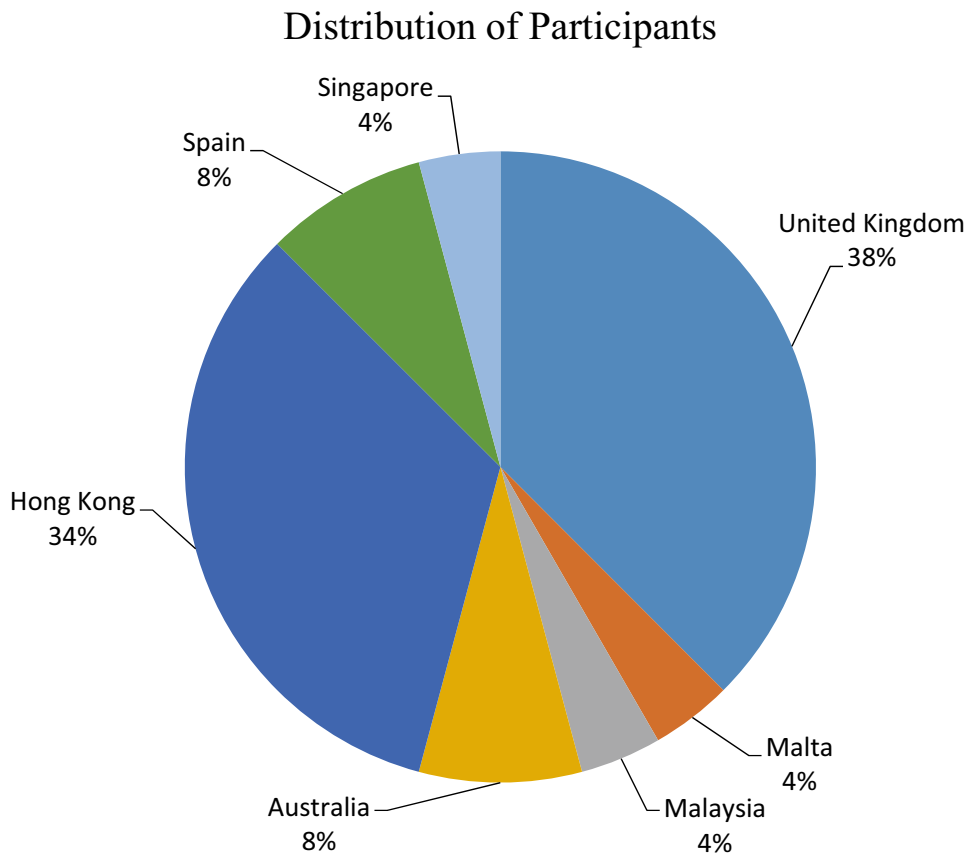


Fig. 5 Geographical distribution of the respondents

4.1.2 Survey Results

In Table 2, the mean scores of Q1 and Q2 are 3.38 and 3.46, respectively. One hundred per cent of the users agreed or strongly agreed that the AI application could enhance their learning, while 95.83% of the users agreed or strongly agreed that the application could enhance their performance. In Q3 and Q4, 16.67% of the users disagreed that the AI application could regulate their practising habits and 91.66% of the users agreed that the AI application could enhance their musical memory (e.g., of accidentals or musical patterns). In Q5 and Q6, 91.66% of the users agreed that

Table 2 Results of the online survey

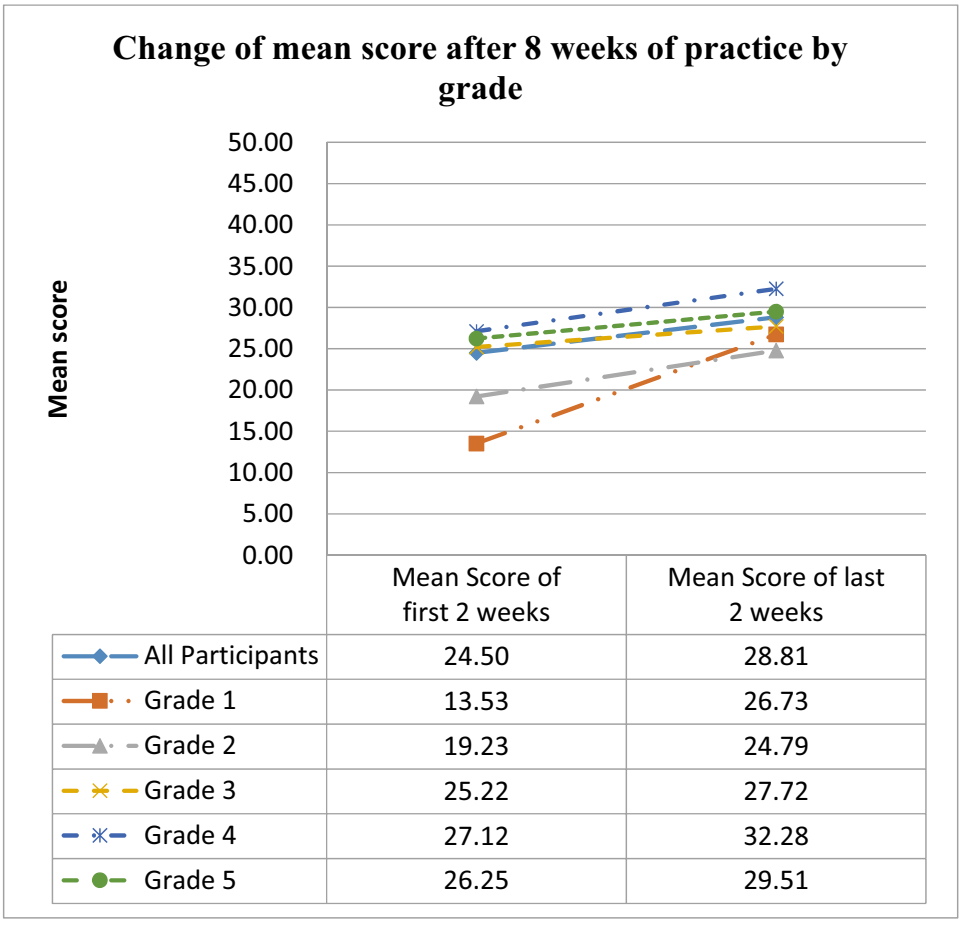
Question	Strongly disagree (%)	Disagree (%)	Agree (%)	Strongly agree (%)	Mean score
Q1. Using the AI application to practise scales can enhance my learning	0	0	62.5	37.5	3.38
Q2. Using the AI application to practise scales can enhance my performance	0	4.17	45.83	50	3.46
Q3. Using the AI application to practise scales can regulate my practising habits	0	16.67	62.5	20.83	3.04
Q4. The AI application can enhance my musical memory (e.g., accidentals and musical patterns)	0	8.34	70.83	20.83	3.13
Q5. The AI application can enhance my confidence in playing scales and arpeggios	0	8.34	45.83	45.83	3.38
Q6. The AI application can improve my motor skills (e.g., fingerings and muscle memory)	0	4.17	62.5	33.33	3.29

the AI application could enhance their confidence in playing scales and arpeggios, and 95.83% of the users agreed that the AI application could improve their motor skills (e.g., fingerings and muscle memory).

4.2 File Analysis (Overall Performance)

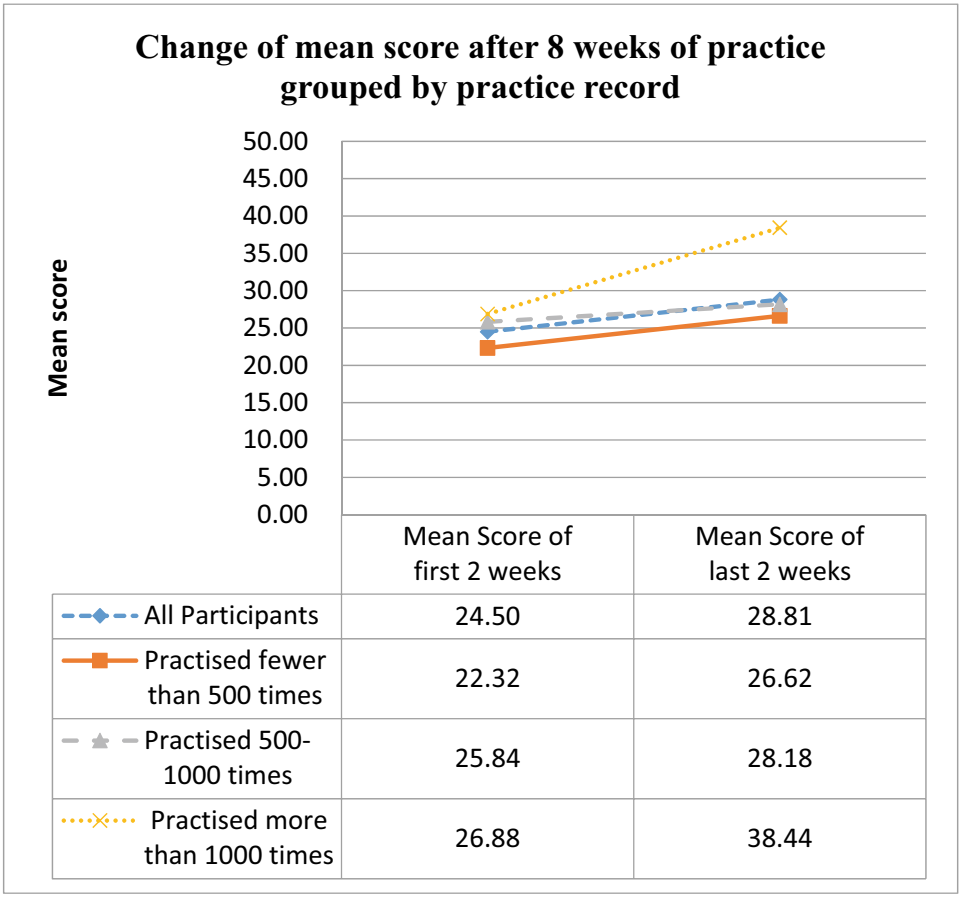
In Fig. 6, the overall performance of the frequent valid users playing five instruments is shown by grade. After 8 weeks of practice with the AI application, a substantial improvement was recorded at the beginner level (Grade 1) with a mean score difference of 13.2. From Grades 2 to Grade 5, good progress was shown, with a mean score difference ranging from 2.5 to 5.56. This trend suggests that the AI application is an effective tool for learning scales and arpeggios at the beginner level (Grade 1) in particular and is also useful in Grades 2 through 5.

In Fig. 7, the change in the mean scores for practice records after 8 weeks of practice is shown. During the 8 weeks of practice, each user was advised to practise each scale or arpeggio at least three times per week. The ABRSM syllabus lists



	Mean Score of first 2 weeks	Mean Score of last 2 weeks
All Participants	24.50	28.81
Grade 1	13.53	26.73
Grade 2	19.23	24.79
Grade 3	25.22	27.72
Grade 4	27.12	32.28
Grade 5	26.25	29.51

Fig. 6 Change in mean scores after 8 weeks of practice by grade



	Mean Score of first 2 weeks	Mean Score of last 2 weeks
All Participants	24.50	28.81
Practised fewer than 500 times	22.32	26.62
Practised 500-1000 times	25.84	28.18
Practised more than 1000 times	26.88	38.44

Fig. 7 Changes in mean score after 8 weeks of practice by practice record

around 15–20 scales or arpeggios to practise in each grade. Users who practised more than 1,000 times in 8 weeks showed the most substantial improvement, with a mean score difference of 11.56. Users with a practice record of less than 1,000 times showed good progress, with a mean score difference of 2.34–4.3.

4.3 Individual Interviews

Individual interviews with in-service studio teachers were conducted. Five instrument teachers were interviewed to investigate how they used the AI application with daily instrument lessons. They were also asked to reflect on what they thought of the AI application as a mobile practising device.

4.3.1 As a Practice Tool

Most of the teachers agreed that the AI application could enhance students' learning. They reported that it functioned as a 'home teacher,' helping students remember what

they learned and what kinds of mistakes they made during lessons. The teachers could use the AI application to monitor their students because it records every instance of scale practice.

> It will be easier for teachers to monitor students' practice record and how they perform. (Teacher C, interview, 1 April 2017)

4.3.2 Visualising Fingering Patterns

A chart that shows the correct fingering can help students improve their visual memory of fingering. Most of the teachers mentioned that students could easily forget the fingering after the lesson, and so would not be able to practise the scale at home.

> While there is no teacher there, they can still remember the fingering. (Teacher B, interview, 1 April 2017)
>
> When the students use the AI application, they pay more attention to the screen and the fingering. (Teacher C, interview, 1 April 2017)

4.3.3 Demo Playback and AI Feedback

All of the teachers agreed that the demo and playback function was the most effective function in this application. This function can develop students' ear training.

> After hearing the demo playing, they imitate, practise and perform better. (Teacher A, interview, 1 April 2017)
>
> Most students do not know what they have played wrong; this function can help them clarify their problem, showing where they have played wrongly so that they can correct it immediately. Also, they can also find out the mistakes by themselves without teachers to train up their self-learning skills and listening skills in order to stimulate their musical sense. (Teacher A, interview, 1 April 2017)
>
> AI feedback can increase learning efficiency and point out the mistake so that students can correct it immediately. (Teacher C, interview, 1 April 2017)
>
> Most of the students do not know they are practicing incorrectly, but this AI function can clearly show what mistakes they have made in order to help them correct them at home. (Teacher E, interview, 1 April 2017)

4.3.4 Intonation

Intonation is the hardest part of practising scales and arpeggios, as students have no idea what it is or how it can be improved.

> After receiving comments and advice from the AI application, students know where they perform well and where they are not in tune. This can enhance their learning effectiveness. Their intonations have improved since practising with this application. (Teacher C, interview, 1 April 2017)

4.4 Response to Research Questions

1. Is the AI application an effective tool for practising scales and arpeggios?

In Table 2, the mean scores of Q1 and Q2 are 3.38 and 3.46, respectively. One hundred per cent of users agreed or strongly agreed that the application could enhance their learning, and 95.83% of users agreed or strongly agreed that the application could enhance their performance. However, in Q3, 16.67% of users disagreed that the AI application could regulate their practising habits. In an interview, Teacher C stated that *'It will be easier for teachers to monitor students' practice record and how they perform.'* This means that even though the teacher may monitor students' practice, the students do not necessarily become self-regulated learners.

From student perspective, 91.66% of users agreed that the AI application could enhance their musical memory (e.g., of accidentals and musical patterns) and 95.83% of users agreed that the AI application could improve their motor skills (e.g., fingerings and muscle memory). Teacher C claimed that *'AI feedback can increase learning efficiency and point out a mistake so that students can correct it immediately.'* The AI application can enhance students' musical memory and motor skills by pointing out intonation mistakes immediately during their daily practice, which enhances the effectiveness of each practice session. However, the open-ended responses on the survey commented that there are delays in the audio signal which could frustrate the learner and discourage further practice with the AI application.

2. To what extent does the AI application enhance mobile practising?

This study has two major findings. The first is that a substantial result is recorded at the beginner level (Grade 1), with a mean score difference of 13.2 for all five instruments. The second is that users who practised more than 1,000 times in 8 weeks had the most substantial result, with a mean score difference of 11.56.

3. How can mobile practising be implemented in studio teaching?

This AI application serves as a post-lesson teacher. Teacher E claimed that *'most of the students do not know they practice incorrectly, but this AI function can clearly show where mistakes they have made in order to help them correct them at home.'* Therefore, blended learning can be adopted in studio teaching in the future. AI makes it possible to incorporate mobile practising as a complement to private studio teaching.

5 Discussions and Conclusions

5.1 Engage Learners in the New AI Learning Environment

The use of AI has changed our daily lives, including music education. Students can engage and listen to demonstration recordings and see the fingering on the screens of their mobile devices. AI can provide comments and immediate feedback to improve students' practice at home or elsewhere. The pre-exam mode can provide marks and comments to help students prepare for their ABRSM instrument examinations, which can save time for instructors. Therefore, instrument instructors can spend more time teaching musical styles and instrumental techniques.

5.2 The Changing Role of Learners and Educators in Mobile Practising

The traditional way of practising scales and arpeggios mainly relies on the instrument teacher to demonstrate the fingering and articulation during private lessons or instrument classes. Students may forget the instructions and then practise in their own way at home. Sometimes students practise something incorrectly or contrary to the instruction of the teachers. The teachers, however, must wait for the next lesson to check whether students have practised well. There is no doubt that scales and arpeggios are the foundation of classical music. Effective practising is therefore crucial. Mobile learning and AI can improve the mode of practice. In this pilot study, the feedback of the users and instrument teachers on the use of recorded data was positive.

5.3 The Future of AI as Blended Learning in Music Education

The use of AI in blended learning can prevent errors in practising. This can save teaching time and allow the teacher to monitor students' progress in practising. However, teachers have commented that when users have too many records in the application, delays are caused by the process of rendering the audio signals from the application's server. If this technical issue causes users to lose patience, they may choose to practise in the traditional way. Therefore, the usefulness of blended learning relies heavily on the technical capabilities of the application.

5.4 Limitations

As this is a pilot study with 24 valid users (n = 24) on five instruments, the present findings cannot be generalised to all users. Furthermore, this AI application is available only on iPhones and iPads due to the technical requirements of the audio engine. This restriction further limited the recruitment of volunteer users.

Acknowledgements Thank you to Mr. Eric Yung for his tremendous support in this research and to my research assistant, Tsang Long Sing, for help during the process of data collection.

Funding Acknowledgement This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

Benetos, E., Dixon, S., Giannoulis, D., Kirchhoff, H., & Klapuri, A. (2013). Automatic music transcription: Challenges and future directions. *Journal of Intelligent Information Systems, 41*(3), 1–28.

Conati, C., Porayska-Pomsta, K., & Marvrikis, M. (2018, June). *AI in education needs interpretable machine learning: Lessons from open learner modelling.* Paper presented at the 2018 ICML Workshop on Human Interpretability in Machine Learning, Stockholm, Sweden. https://arxiv.org/pdf/1807.00154.pdf.

Chen, J. (2015). Mobile learning: Using application Auralbook to learn aural skills. *International Journal of Music Education, 33,* 244–259.

Franke, J. (2013). Violin scales: Strategies for improving intonation. *American String Teacher*, May, *63*(2), 74–75.

Johnson, L., Levine, A., Smith, R., & Stone, S. (2010). *2010 Horizon report*. Austin, TX: New Media Consortium.

Johnson, M. (2014). *In touch with the wild: Exploring real-time feedback for learning to play the violin.* PhD thesis. London, United Kingdom: University College London.

Melhuish, K., & Falloon, G. (2010). Looking to the future: M-learning with the iPad. *Computers in New Zealand Schools: Learning, Leading, Technology, 22*(3), 1–16.

Rossing, J., Miller, W., Cecil, A., & Stamper, S. (2012). iLearning: The future of higher education? Student perceptions on learning with mobile tablets. *Journal of the Scholarship of Teaching and Learning, 12*(2), 1–26.

Warwick, K. (2012). Classical AI. In *Artificial intelligence: The basics.* New York: Routledge, 31.

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