Impact of AI Software on Improving Learning Outcomes and Attitudes of Music Students in Chinese Vocational Schools

Ren Jiuzhou[1], Bosede Iyiade Edwards[1]*, Nurullizam Jamiat[1]

[1] *Centre for Instructional Technology & Multimedia,*
Universiti Sains Malaysia (USM), Minden, 11800, MALAYSIA

*Corresponding Author: bosede@usm.my

Abstract

This study focused on the application of AI tools in vocational music education. The objective is to determine whether the use of AI tools can help improve music listening and reading skills, thereby helping to address the challenges of access to quality music education by students in poor districts with limited access to learning resources. In a within-subjects experimental procedure involving 44 vocational school students (22 male, 22 female) aged 14-17, participants underwent 3 weeks of learning music listening and reading without technology support (condition 1) and learning with AI support (condition 2). Kimi Assistant AI tool was employed for teaching music listening while Music notation software (Laiyinzhipu) was employed for teaching music reading. Students were tested for both learning and attitude. Three (3) hypotheses were also tested to assess the impact of AI tools on music listening, reading and students' attitudes. Findings show that using AI software specifically promoted only Melody and Structure indicators in listening skills whereas all the reading skills show marked improvement with AI tool. The implication of this is that AI software might hold more effectiveness regarding the teaching of reading skills. A significant improvement in attitude was also noted with the use of AI tools. However, more in-depth studies are needed to confirm if there are clear correlations between learning outcomes and attitudes with the use of AI software can help students improve their motivation to learn. The study is novel in its focus on music education. The study further shows that a combination of AI software and teacher-led instruction will be more significantly beneficial to students for learning music courses. Recommendations for future studies address the limitations of the study including the short experimental period, software restriction issues, an exploration of learners' motivation, and studies adopting other designs including surveys and other experimental methods.

1. Introduction

Music as an important form of art has both cultural and social values in human society. Music education plays a crucial role in personal and cultural development, particularly in China's evolving educational landscape. As China continues to grow its international appeal, its focus on various forms of arts, including music, is increasingly stronger. The benefits of music education has been noted to include the development of emotion recognition,

understanding emotions, emotional self-regulation, responsibility, empathy, social relationships, self-expression and self-criticism (Váradi, 2022). As a result, music education has become a compulsory subject that often includes music content (elements, literature and history) and music skills (reading, listening, singing, performing, moving, and creating) (Suwanphithak et al., 2023). However, despite its recognized benefits, vocational schools often struggle to provide comprehensive music education due to resource constraints and teacher shortage. This study explores an innovative solution, leveraging Artificial Intelligence (AI) software to enhance music listening and reading skills among students in Chinese vocational schools. The study focuses specifically on designing and testing a music learning system for music appreciation using generic AI software among vocational school students. The impact of the AI software on students learning outcomes in music, with specific focus on music listening and music reading will be evaluated in addition to students' attitude to learning music appreciation when they learnt with and without an AI tool.

With advancement in technology, especially Artificial Intelligence (AI), several tools have become available to support learning of various subjects including music, in Chinese vocational schools (Kabudi, 2022). While it is generally assumed that technology-assisted instruction is superior to traditional instructional approaches (Clark & Mayer, 2012; Tabbers et al., 2004; Yamauchi, 2008), courses and subjects that are vocation-based or reliant on affective or psychomotor skill might not always be best taught with tools. Music listening has strong affective influences (Huang, 2024; MacIntyre et al., 2018) whereas music reading is more cognitive, depending on the ability of the learner to 'identify' and 'recognize' music staves. Focused study of technological tool application in these skill areas might therefore provide deeper understanding on the potential effectiveness of different pedagogical approaches in promoting more effective instruction in these skill areas.

While AI research in music education started a little later (in the 1980s), compared to other disciplines, a growing body of research is proving that teachers can use AI software to help students learn music better and at lower cost (Holster, 2024; Milakis et al., 2024; Shang, 2019; Waddell & Williamon, 2019; Wang, 2024) (Holland, 2000). Extensive research has not been reported on skills in the music appreciation course and a gap still exists in whether or not, and how AI can be leveraged to support skills like music reading and listening, especially in poor regions where students cannot afford the cost of private tutoring or musical instruments. This study therefore examines the impact of two AI software on learning outcomes in music appreciation, specifically, the Kimi Assistant software for music listening skill, and Music Notation (formerly Laiyinzhipu) for music reading among Chinese vocational school students.

2. Literature Review

2.1. Vocational Education

Vocational education focuses on teaching practical skills for specific jobs or trades. It has been described as "qualitative technological human resources development directed towards a national pool of skilled and self-reliant craftsmen, technicians and technologists" (Okoye & Arimonu, 2016). Because it is directly linked to various personal interests, vocational education may offer individuals greater job satisfaction and fulfillment. Apart from its benefits to individuals, vocational education is also beneficial to the larger society as it helps to develop a skilled workforce that not only meets the needs of industries and businesses but can also contribute to economic growth and innovation. National investments in vocational education and training is thus seen as a feature in many countries (Okolocha, 2016; Jabarullah & Iqbal Hussain, 2019; Wilunda et al., 2015).

2.2. Vocational Education in China

To realise the goal of national industrial upgrading, the Chinese government has increased investment in vocational education resources since 2012, and vocational education has entered a stage of rapid development (Jing & Keat, 2024). According to China's Ministry of Education's annual public information, in 2023, the number of higher vocational education schools in China has exceeded the number of ordinary universities, with vocational university currently recruiting 90,000 students and college enrolment climbing above 5.5 million. The number of vocational high school enrolments is also above 4.5 million.

Although China has increased its investment in vocational education, several issues still persist. Teacher shortage and high dropout rate have been identified in addition to low quality teaching. There is also social prejudice against music learners (Q. Liu & Pan, 2024). The study also noted a correlation between the number of enrolled students and teachers' salaries and how this directly impacts teacher- student ratio. Although these schools are set up by the government, they have to recruit more students to have enough funds to pay teachers' salaries. This expansion of enrolments has also led to a large gap in students' learning and interest. Muller's (2024) study on the cooperation between China's vocational education and enterprises show that there is a large gap between China's vocational education and market demand, with resultant lack of enthusiasm for learning among students. In their historical review of China's vocational education, Jing & Keat (2024) pointed out that China's

vocational education relies heavily on national policies, and this is directly linked to the rigidity of curriculum and learning content and methods in vocational schools.

2.3. Vocational Music Education

The music curriculum requirements of the Chinese Ministry of Education for compulsory education from primary to junior high school and senior high school are roughly the same as these contents. Compared with the basic knowledge in primary and junior high schools, the Chinese Ministry of Education requires the music curriculum in high schools to include three parts identified as aesthetic perception, cultural understanding and artistic expression. The first two are merged into the music appreciation course which serves as the basis for musical knowledge, in primary and junior high schools, and the basis for the content of artistic expression (Z. Chen, 2024). Musical skills that fall under the artistic expression category (e.g. singing and acting), can easily be learned in non-school settings (for example at social events and cultural festivals). Those in the aesthetic perception and cultural understanding category, that is, skills in the music appreciation course (musical content, reading, and listening) require some expert support to master. Unfortunately, the acute shortage of qualified music teachers in many schools, especially in Chinese vocational schools is further complicated by the poor funding and lack of learning resources like musical equipment. Students in vocational schools therefore have restricted access to good music education (Jing & Keat, 2024). Supporting these students to access music learning resources is an important step towards tackling inequalities, promoting equitable access to quality education, and realizing global social justice. The Chinese Ministry of Education has only recently included music as an optional part of compulsory art education and a key learning subject in the new curriculum standards (Z. Chen, 2024). Under the new standards, schools are required to choose between music and painting as part of the art curriculum. The music course has no specific content requirements except for 'cultivating students' aesthetic ability of music' and some course indicators. Some of these indicators, for example, the requirement that junior high school students who are not music majors can 'conceive musical works and create songs with musical scores' are out of touch with reality, and forcing teachers to 're-design' curricula based on past experience.

While the Chinese government has begun to accelerate the construction of vocational education in the last decade, several challenges still remain. The strong influence of government policies on vocational education also meant that schools are unable to make significant adjustments to their curricula. This leaves teaching and learning of vocational subjects, including music to the creativity and commitment of teachers to supporting student learning.

2.4. Music Education and Music Appreciation

Music education has become a very important part of the modern education system, with roles beyond cultivating students' musical skills, but also emotional cultivation, aesthetic quality and all-round development (Feng & Peng, 2024). In her article on the importance of music education and its influence on learning and cognition, Wang (2024) noted that music education can improve students' art cognition and cultivate students' imagination. Music education also plays a role in the cultivation of personal emotions and social communication skills. Varadi (2022) in her review makes a strong case for the social and emotional impact of music education. This includes the development of emotion recognition, understanding emotions, emotional self-regulation, responsibility, empathy, social relationships, self-expression and self-criticism.

In China, the musical ability that students are expected to master in school is generally captured as 'aesthetic ability', however, there is no official or academic definition of this ability. Huang (2024) defined musical aesthetic ability as an individual's ability to appreciate and judge music, which is not only the perception and understanding of musical works, but also the emotional experience and cognitive thinking about music. Jing and Keat (2024) believe that to improve students' musical aesthetic ability, it is necessary to improve students' basic musical accomplishment, and the abilities of music appreciation and performance. While music appreciation requires students to understand the emotional content expressed in musical works, music literacy refers to the understanding of the basic content of music, such as theme, melody, section and other elements often mentioned in music learning. The cultivation of aesthetic ability can thus be regarded as the process of mastering, understanding, and using musical knowledge.

2.5. Curriculum Practices in Chinese Vocational Music Education

In curriculum practice, the effects of the lack of resources in vocational schools have become apparent. In the development of music curriculum in Hubei (Zhou, 2018), according to the actual situation of students and school equipment, a vocational school retained the two parts of music appreciation, while basic music knowledge was removed from the curriculum design, and the two parts were merged into a new curriculum.

Yingben (2021) also conducted research on the music textbooks of a vocational school in Guangdong Province; she recommended that since each school's situation is different, each school should develop its own music

curriculum according to its own situation and the requirements of the Ministry of Education. In practice, the school abandoned the music performance content, reduced the basic knowledge of music, and recombined the remaining content with the music appreciation content into a new music appreciation curriculum. A similar move was made in East China where many local schools redesign the content of music courses based on contextual situations like insufficient teaching time or other reasons. However, music appreciation courses as a foundation are maintained in all school options. These studies of different vocational schools in east, central and south China highlighted similar conclusions: based on individual contextual situations or limited resource availability, schools modified the music appreciation curriculum to suit the situation of the school and completed the curriculum requirements as much as possible.

In China's music education system, students are theoretically required to master the basic knowledge of music, and the ability to appreciate and perform music. However, because vocational schools are underfunded and short-staffed, they have to adapt their curriculum for the music appreciation course. The music appreciation course has become the only systematic music knowledge that students in vocational schools can learn. The study of the music appreciation course has thus become important and necessary.

Based on Dai's (2024) indicators for piano teaching, and feedback from the music teachers, the content of the music appreciation course is divided into reading skill and listening skill. These skills are further sub-divided into three (3) dimensions, five (5) secondary indicators, and seventeen (17) primary indicators as shown in Table 1. Each of the 17 indicators is briefly explained in parenthesis.

Table 1 *Dimensions of the music appreciation ability evaluation index in vocational schools*

Music Skill	Dimensions	Secondary indicator		Primary indicators
Listening skill	Identifying acoustic	Music essentials	1	Instrument name
			2	Timbre (sound)
			3	Pitch (how low/high)
			4	Texture (emotional feel)
			5	Duration (note length)
			6	Melody (sequence of notes)
			7	Rhythm (flow/beat)
			8	Tempo (speed of the beat)
			9	Structure (parts of the music)
	Composition understanding	Analysis composition	10	Musical performance (form)
			11	Musical composition
			12	Creative background
		Affective expression	13	Emotional experiences
Reading skill	Know stave	Chinese easy stave	14	Understand it
			15	Sing it
		Musical stave	16	Understand it
			17	Sing it

2.6. AI Software and Music Education

With advancement in technology, many AI software are been used in education. Shang (2019)'s study on AI in music education found that AI has not only revolutionised the creative aspect of music, but also influenced the design of teaching and learning in music education. Liu (2023) noted that AI software can provide supplementary means for addressing the lack of musical equipment, thus helping to combat the economic issues surrounding music instruction. In his study of ChatGPT in music education, Holster (2024) also found that AI software can help students understand musical knowledge and elements used in music in the absence of musical instruments. AI can also provide support for self-learning.

Most AI in music education studies used one of two approaches. Either to develop special AI teaching software or to support teaching plans. For example, in their MUSENSE project, Deliyannis, et al. (2024), noted that the project included AI, IOT (Internet of Things), robotics and eXtended (XR)/virtual (VR)/augmented (AR) reality and other emerging technologies to enhance music education and performance. The initial findings suggest a positive impact on music education. Li (2024) in his study on AI technology and university music education system also submits that the development of special AI software for music education would be helpful for student learning, although the development or use of such software would come at a cost that might be unaffordable for many schools and students.

An alternative, and practical approach would be to use general-purpose AI software to support teaching. Milakis (2024), in his research on music education using ChatGPT4, he believes that generative AI tools can help students prepare materials for music courses and integrate students' musical interests into the curriculum. Deliyannis (2024) however, argues that teachers' acceptance of technological software has a great influence on the effectiveness of the software.

Extensive research on AI in music education has proven that AI software can help develop and teach music courses. For qualified schools, or schools with adequate funding, AI software or teaching systems developed specifically for music courses can be adopted. However, for schools with limited access to funds and equipment, general AI software can help to support students' learning of music courses. However, it is necessary to pay attention to the teachers' acceptance of the software.

2.7. Theoretical Framework and Hypothesis Development

Atkinson and Shiffrin's (1968) widely accepted multistore model of the human information processing system provides a basis for the Cognitive load theory (CLT) proposed by John Sweller (1988). The multistore model posits that human memory is divided into the sensory memory (SM), short-term memory (STM) and long-term memory (LTM) stores, and that important content received on daily basis become LTM only if properly processed through the previous two memory stores and stored appropriately in the LTM. CLT refers to different types of memory content as cognitive load (CL), and divides CL into intrinsic, extrinsic, and germane loads.

Intrinsic is native to the learning material and is related to element interactivity in the content (O. Chen et al., 2023; Leahy et al., 2015). Extrinsic CL is added unnecessarily to the learning process either due to unsuitable teaching methods or other distractive influences during learning; it interferes with the learning process by using up cognitive processing resources that should have been applied to effectively learning the material or content. Germane CL arises from the introduction of methods or techniques to help students in the learning process. All three CLs increase the stress of learning for students, and if CL can be reduced, it will reduce the distraction of the learner's attention and promote better learning. Therefore, teachers need to make effort to reduce students' extraneous CL by adjusting the instructional methods and approaches. Several studies have confirmed the significant role of software in promoting cognitive load management. Tools that are particularly suited to helping with managing element interactivity or supporting self-paced and personalized learning are very useful in managing CL. This study is based on the assumption that using AI software as a tool for adapting a music appreciation course will help to reduce students' extraneous CL, thereby improving their learning outcomes and promoting positive attitudes.

It is generally believed that a positive social environment can enhance human motivation and ultimately, achievement by supporting the satisfaction of three basic psychological needs: autonomy, competence, and relatedness. It is believed that all the three components of SDT are positively correlated (Ryan & Deci, 2000), and contribute directly to motivation and engagement, which in turn directly impacts performance and well-being.

Evans (2015) suggests that there are positive and negative supportive behaviours regarding the three indicators of SDT in music learning. Pete et al. (2018) also proposed optimising the original SDT into perceived competence, motivational intensity and learning desire, arguing that the three psychological needs that make up perceived competence affect motivational intensity for learning, and because of the complexity of motivation, it cannot be simply assumed that perceived competence directly constitutes motivation, but rather affects motivational intensity. Students' desire to learn will be influenced by their motivation to learn, and it is the desire to learn, together with other objective conditions, that inspires students' learning achievement.

By combining the elements of the SDT and CLT, this study aims to verify whether students' test scores and attitudes improve after using AI software for learning music appreciation compared with learning through traditional, teacher-led approaches without AI. The study focused on examining music listening and music reading skills being the two parts of the music appreciation course in Chinese vocational schools.

The study will focus on three (3) key objectives including: 1) designing a music learning system for music appreciation using generic AI software, 2) evaluating the impact of the AI software on students learning outcomes in music listening and music reading and 3) assessing if there are any changes in students' attitude to learning music appreciation when they learnt through traditional methods compared with learning with AI tool. Based on these objectives, the following hypotheses are put forward:

H01: AI software for learning music appreciation will improve the music listening skills of vocational students.
H02: AI software for learning music appreciation will improve the music reading skills of vocational students.
H02: AI software for learning music appreciation will improve student attitudes to vocational music learning.

3. Methodology

3.1. Research Designs

The study adopted a within-subjects design with each participant experiencing both the standard (traditional) as well as the AI-supported learning conditions. This design has no need for a control group, thereby eliminating threats associated with a 2-group designs. There were 4-weeks of music learning covering listening and reading skills in the music appreciation course.

3.2. Study Context and Participants

A vocational junior high school in a city in an eastern Chinese province was selected for the experimental study. The city is classified as a fourth-tier city in China's administrative system. It has an urban area of 4,743 square kilometres, a poor urban economic status and a public debt of 43 billion RMB. The city invested in education at a 20 percent increase for three consecutive years, as required by the state, but the vocational secondary schools that took part in the test did not add any Arts subjects and did not equip music classes with instruments due to financial constraints.

Participants in the study were 44 students, aged 15 – 17 consisting of 22 boys and 22 girls in line with Chinese middle schools' design on equal numbers of boys and girls. The teacher involved with the study was a music part-time teacher recruited by the vocational school. The teacher was female, 52 years old, does not have a bachelor's degree, but has over 30 years of music teaching experience, is an associate professor of music, and holds an advanced professional level certificate.

3.3. Development of the AI Tools and Learning Content

Due to the national restrictions in mainland China, Google framework-based software and others based on oversea support cannot be used. As a result, software choice is limited to suitable ones available and accessible in mainland China. In addition, due to limited funding and the students' financial situation, the selection of AI software was limited to open-source software. To function properly for the intended purpose, the selected software, among other things, must be able to recognise images, accept file upload, recognise sounds, have no copyright restrictions or computing power limitations, and able to integrate web information and respond to text input. The next sections describe the two (2) software employed in the study. Table 2 provides a summary of how the AI tools' functions align with the target music skills in the study.

3.3.1. AI Tool for Listening Skill: Kimi Assistant

Kimi Assistant, developed by Moonshot (Zhang, 2024), was chosen to aid the music listening content development. Kimi Assistant is a specialized AI-powered software designed to support music education by offering interactive, personalized assistance in developing music listening and analysis skills. It leverages artificial intelligence to provide tailored feedback, exercises, and analysis that help students engage more deeply with musical elements like melody, harmony, rhythm, and structure. The software's functionality and adaptability make it a promising tool for educators who aim to enhance students' listening skills in a way that's both engaging and educational. The researcher designed the teaching system and test, working in collaboration with the music teacher on content development and also trained the teacher to use the AI tool. The teacher was fully responsible for all aspects of teaching throughout the study.

Listening skill covered the 13 indicators (Table 2) with skills assessed based on students' ability to demonstrate the indicator being measured. For example, differentiating between the sounds of different musical instruments after listening to the sound played or recognizing melodies from audio, being able to determine duration (note length), or rhythm (beat) or differentiate between different tempo (speed) for the same melody. Students were also expected to be able to identify a music piece structure (parts).

3.3.2. AI Tool for Reading Skill: Music Notation

Music reading skill was based on ability to read the music stave. Reading skills are considered more difficult to learn because students do not come into regular contact with the stave, and class time is generally not enough for students to master this skill in class. An AI software that can help students learn and read the stave outside class time is considered beneficial for learning.

Music Notation software (来音制谱, Laiyinzhipu) developed by Beijing Xihang Technology Co. (BXTC) was employed for teaching music reading in the study. Music Notation is a versatile digital tool for music educators and students focused on teaching and learning music reading skills. It offers an accessible platform for creating, editing, and sharing sheet music, catering to learners of different levels. The software provides a streamlined, interactive environment to practice reading and understanding music notation, making it a valuable resource for both in-classroom and self-paced learning. The software is freely available for download, and it can convert sheet music into different formats of musical stave or Chinese easy stave based on the photos of the sheet music, thus supporting learning of music reading skills.

The learning process for the reading skill with the software was a 2-step process. During the physical class session, the teacher teaches the students how to install and use the software. The teacher plays a music piece in its entirety first, then, she plays the music against the stave to teach the students how to read the stave. Students then use their mobile phones with the software to read the stave and play the music. After the class, the teacher provides the students with printed staves and the students use the software to scan the stave and listen to the music written on it. The students are then assigned a music reading homework which they have to present (sing) during the next class.

Table 2 *How the employed AI tools' functions align with the target music skills in the study*

	Kimi assistant software	Music Notation software
1	*Adaptive and incremental learning support*: for a gradual development of listening skills and preventing cognitive overload.	Interactive drills and playback feature simulate real-life music reading and promote immediate recognition of notes, rhythms, and accurate reading skills.
2	*Active listening support* engages and helps understanding of interaction and integration of musical components an overall piece.	Key signature changes, transpositions, and rhythm features reinforce music theory understanding.
3	*Technology-enhanced learning* supports engagement among modern, tech-savvy students and digital-natives.	Playback feature, shareable files, and real-time feedback support remote and multisensory learning and reinforces comprehension different learning preferences.
4	Instant, data-driven feedback supports immediate correction of mistakes and better retention.	Practice modes and the flexibility to complete exercises independently supports consistent practice and accelerates reading proficiency and confidence.
5	Spectrograms and waveform multimedia tools support analytical listening skills and multi-sensory learning and non-auditory learners for auditory learning	Error highlighting and immediate, guided corrections allows learners to correct errors on the spot, making practice sessions more effective.
6	Support for self-paced learning: Mobile and applicable in and outside the classroom, supporting flexible and self-paced, anytime, anywhere learning.	Flexible and adaptable to various skill levels from beginners to advanced.

3.4. Instrumentation

A 17-item test was developed to assess students' music skill acquisition based on the 17 indicators in Table 1. To assess students' attitudes to learning, a 2-part questionnaire was designed to assess students' learning attitude and students' perception of learning outcomes in music listening and reading. The questionnaire design was based on Ju and Chong (2023)'s survey on students' attitude towards learning piano lessons and the three dimensions of behavior, attitude and cognition by Li and Wang (2023). There were six (6) items on students' attitudes towards learning and four (4) items on students' perception of own achievement in reading and listening skills.

3.5. Study Procedure

For the listening skill, there was a 2-step procedure including a pre-class and an in-class session as shown in Figure 1: The pre-class session was a self-learning session during which the students used the software to preview the learning content. The in-class session was a teacher-led instruction session. The teacher demonstrates the use of the AI software to the students to help them learn how to use it. The flow of the 9-week study procedure is shown in Figure 1 while Figure 2 presents a flowchart of the experiment with the AI software and the various pre-course, in-course, and post-course learning activities.
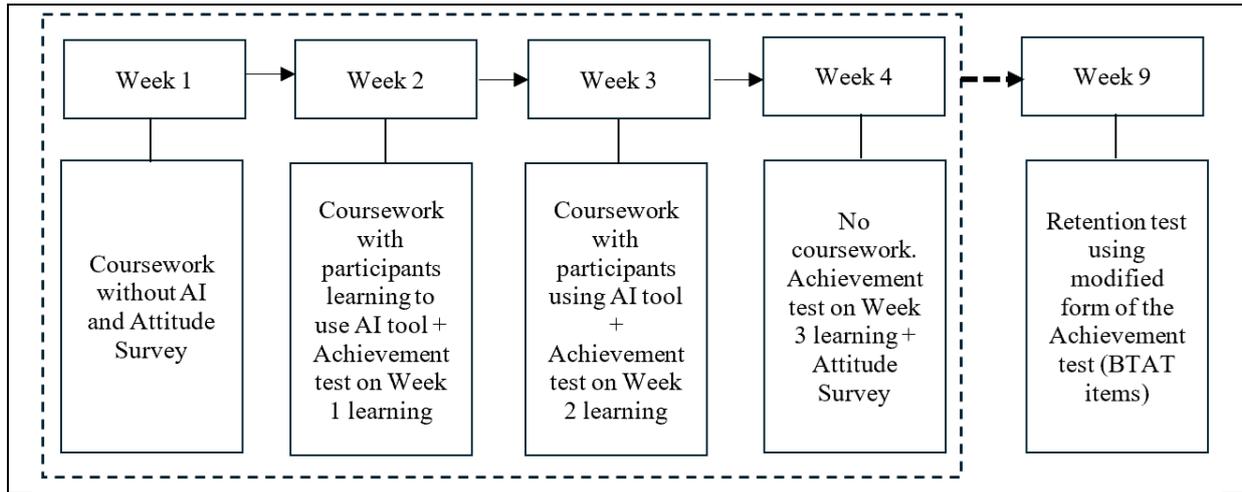
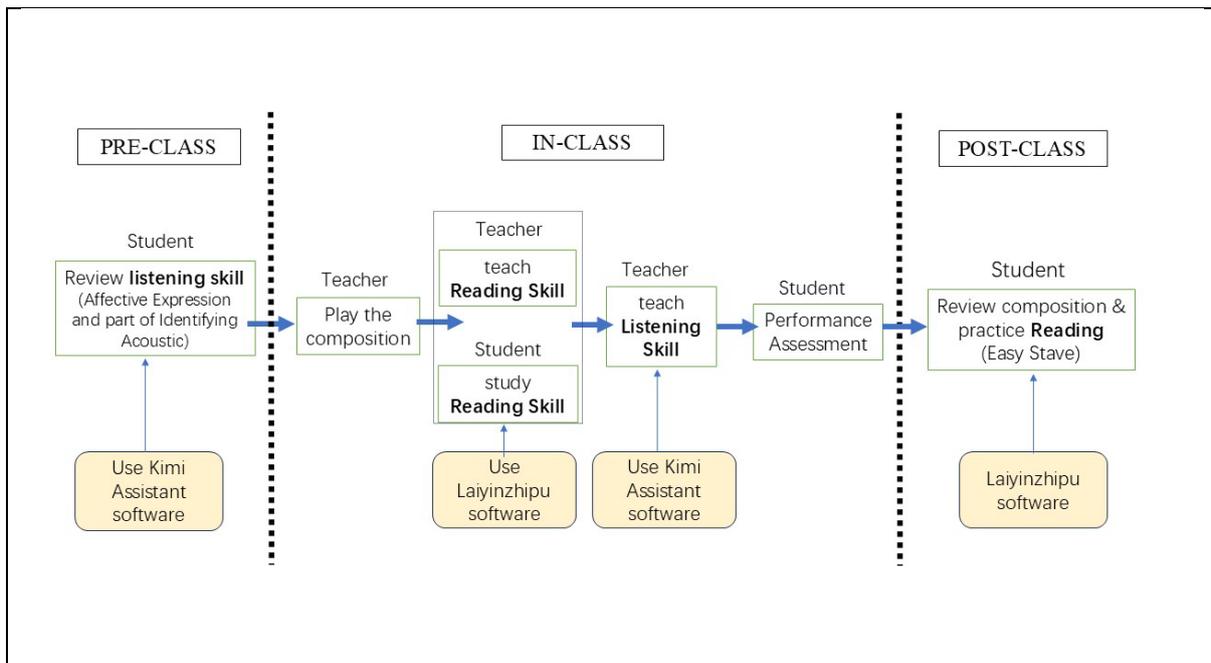**Fig. 1** *Flow of the 9-week study procedure*

Fig. 2 *Flowchart of the experimental study with the AI software*

The music content was based on three traditional Chinese music pieces shown in Table 3. Students learn both listening and reading skills. The music course followed a traditional instructional model and a technology-aided approach that incorporates the use of AI software. A different piece of music was used each week but the same test was conducted as shown in Table 2. At the end of the course, the musical skills test is administered in addition to tests of students' attitudes towards learning. The first week focused only on traditional learning with no AI used. Student were tested for mastery of the skills taught in one week in the following week.

Table 3 *Music content used in the study*

Week	Music piece used	Activity
1	Two Fountains Reflecting the Moon	Learn music piece traditionally
2	The Butterfly Lovers	Tested for 'Two fountains' (traditional learning) and learn Butterfly lover using AI tool
3	Jasmine	Tested for 'Butterfly lover' and Learn using Jasmine (AI learning)
4	N/A	Tested for Jasmine (AI learning)

4. Results

Data collected include achievement test scores for music listening and reading, and attitude survey. The data were statistically analyzed using SPSS version 27. Reliability assessed based on Cronbach α for the attitude survey instrument (SAS) was 0.843, indicating a high level of internal consistency and reliability among the items. In most fields, an alpha between 0.7 and 0.9 is viewed as satisfactory to high and suggests that the items work together cohesively (Taber, 2018; Zipse et al., 2014), typically indicating that the items on the survey are well-correlated. An alpha value of 0.843 therefore indicates that the items on the survey are well-correlated to measure attitudes.

4.1. Learning Outcomes of Music Listening and Music Reading Skills

Descriptive statistics for the test scores are presented in Table 4. The data shows an overall improvement in students' test scores after studying with the AI software compared to learning without AI software.

Table 4 *Descriptive statistics of test scores*

Test Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Identifying acoustics										Composition Understanding				Know Stave			
	Music essentials										Analysis composition			AE*	Chinese easy stave		Musical stave	
Pre-class (%)	93.2	68.2	84.1	86.4	90.9	88.6	68.2	70.5	90.9	81.8	81.8	61.4	50	40.9	31.8	20.5	11.4	15.9
In-class (%)	95.5	79.5	90.9	90.9	93.2	95.4	75.0	72.7	97.7	81.8	84.1	75.0	84.1	93.2	63.6	72.7	50.0	52.3
Post-class (%)	100	81.8	95.5	95.5	95.7	97.6	79.6	79.6	100	88.6	88.6	81.8	100	100	86.4	79.6	63.6	68.2
	6.8	13.6	11.3	9.2	2.3	9.1	11.8	9.1	9.1	6.8	6.8	20.5	50	59.1	54.5	59.1	52.3	52.3
Ratio changes	8.9											25.8		59.1		56.8		52.3

*AE: Affective Expression

However, after examining the secondary indicators, the dimensions and the 2 skill levels reveal deeper insights into the results as follows:

i)   For listening skills, the music essentials category shows a good overall performance after learning without AI but only limited improvement with AI software.
ii)   Reading skills show higher overall scores with AI software compared with no AI.
iii)   Analysis compositions shows higher scores with AI software compared with no AI.
iv)   Affective expression and reading skills show lower scores with no AI, but markedly higher scores with AI software.

4.1.1. Hypothesis 1: AI Software for Learning Music Appreciation Will Improve the Music Listening Skills of Vocational Students

Table 5 shows the t-test of overall test score for learning without and with AI. The results showed a significant difference in test scores for learning without and with AI, indicating that AI has significant impact ($p<0.05$) on the learning process.

Table 5 *T-test of total test score difference*

	Total Score (Mean±SD)		t	p
	Traditional Learning (n=44)	AI Learning (n=44)		
Total Correct rate	0.63±0.02	0.88±0.02	-8.613	0.000**

Individual primary indicators were further examined for significant difference in scores for learning without and with AI. The t-test of difference in test scores shows which indicators were most/least impacted by the intervention. The results presented in Table 6 show significant improvement with AI for only a few elements:

- melody and structure (6 and 9): measuring students' ability to identify and understand musical elements),
- musical composition (12: measuring students' understanding and appreciation of musical composition)
- emotional experiences (13: measuring students' ability to identify and understand the emotional impact of musical elements)

Table 6 *T-test of test score difference for individual primary indicators*

Question Item	Indicator 2°	Indicator 1°	Test Score (Mean ±SD) Traditional (n=22)	AI Learning (n=22)	t	p
1	ME	Instrument name	1.07±0.25	1.00±0.00	1.774	0.083
2	ME	Timbre (sound)	1.32±0.47	1.18±0.39	1.634	0.11
3	ME	Pitch (low/high)	1.16±0.37	1.05±0.21	1.949	0.058
4	ME	Texture (feel)	1.14±0.35	1.05±0.21	1.431	0.16
5	ME	Duration (note length)	1.09±0.29	1.07±0.25	1	0.323
6	ME	Melody (sequence of notes)	1.11±0.32	1.02±0.15	2.074	**0.044***
7	ME	Rhythm (beat)	1.32±0.47	1.20±0.41	1.949	0.058
8	ME	Tempo (speed)	1.30±0.46	1.20±0.41	1.274	0.21
9	ME	Structure (parts)	1.09±0.29	1.00±0.00	2.074	**0.044***
10	AC	Musical performance (form)	1.18±0.39	1.11±0.32	1.774	0.083
11	AC	Musical composition	1.18±0.39	1.11±0.32	1.774	0.083
12	AC	Creative background	1.84±0.37	1.18±0.39	7.193	**0.000****
13	AE	Emotional experiences	1.39±0.49	1.00±0.00	5.203	**0.000****
14	R	Understand it	1.50±0.51	1.00±0.00	6.557	**0.000****
15	R	Sing it	1.59±0.50	1.14±0.35	5.503	**0.000****
16	R	Understand it	1.68±0.47	1.20±0.41	6.266	**0.000****
17	R	Sing it	1.80±0.41	1.36±0.49	4.883	**0.000****

The partial support for H1 suggests that AI software can enhance certain aspects of music listening skills, such as understanding musical composition and emotional responses to music. However, it is evident that AI's influence on other sub-skills, like melody recognition and rhythmic patterns, is less pronounced. This may be attributed to the inherent complexity of these skills, requiring a combination of auditory and cognitive abilities.

Melody and structure were confirmed by the teacher to be skills that require more time for learning and have more complex and heavier content compared with other indicators in the music listening skills category. These two indicators are also rarely used in the everyday classroom. The indicators showing greater improvement with no AI learning are very basic to music listening, they are easier to understand and learn during regular classroom instruction or in other out-of-school settings.

For analysis compositions category (10 and 11), there was marked improvement after learning the course with AI software. This part of the content is also basic, and students answered most of the question items correctly. It is also understood that students do not think about these factors when answering questions because they have little understanding of music works, and the music works are also linked to certain historical backgrounds and social experiences. As such, with the help of AI tools, students were able to get more explanations of musical compositions in a shorter time, and in the process, are better able to understand the content of the category.

Based on the results, we reject the alternative hypothesis and conclude that AI software for learning music appreciation only partly improves the music reading skills of vocational students.

4.2. Hypothesis 2: AI Software for Learning Music Appreciation Will Improve the Music Reading Skills of Vocational Students.

All the four indicators in the music listening category show significant improvement with AI learning (p<0.05). This improvement can be attributed to the interactive and personalized nature of AI-powered learning, enabling students to practice at their own pace and receive immediate feedback. The significant impact of AI on music reading skills is encouraging. It might indicate the potential of AI being more beneficial for higher order skills or

those requiring more contact or learning time that is impractical during regular classroom-based instruction with the teacher. For example, AI might be more beneficial for learning to read the stave (reading skill) by providing opportunities for students to have 'regular contact with the stave', and supplementing class time which is 'generally not enough for students to master this skill'. Overall, the results suggest that while AI-supported instruction may have a significant impact on some music listening skills, it may be particularly effective in improving students' music reading skills, including understanding, recognising and singing musical notation. The stated alternative hypothesis is therefore accepted and we conclude that AI software for learning music appreciation improved the music reading skills of vocational students.

4.3. Students' Attitudes to Learning

4.3.1. Descriptive Statistics for Attitudes

The descriptive statistic for attitude is presented in Table 7. The results show that students' Competence, Relatedness, Autonomy and Achievement perception have all been improved after using AI software for learning, among which Autonomy has the highest improvement and Relatedness has the lowest. The other categories improved by a similar amount to Autonomy.

Table 7 *Descriptive statistics of students' attitude to learning*

	Competence		Relatedness		Autonomy		Self-Perception of Achievement			
Pre-test (%)	34.1	31.8	63.6	25.0	11.4	9.1	59.1	65.9	15.9	43.2
Post-test (%)	47.7	65.9	81.8	41.2	27.3	43.2	79.6	84.1	54.6	63.6
Ratio changes (%) in category	23.9		17.2		25.0		24.4			

4.3.2. Hypothesis 3: AI Software for Learning Music Appreciation Will Improve Student Attitudes to Vocational Music Learning.

Table 8 presents the t-test of difference in attitude scores. It shows five (5) out of the six (6) items show significant difference in student attitudes. The results show that in terms of awareness, attitude and behaviour, participants were more positive with regards to learning with AI compared with learning traditionally.

Table 8 *T-test of students' attitude to learning*

Question Item	Indicator 1o	Test Score (Mean ±SD)		t	p
		Traditional (n=22)	AI Learning (n=22)		
1	The only reason I took music classes was because it was part of the curriculum at school (awareness)	1.34±0.48	1.48±0.51	-1.431	0.160
2	I don't think I've learned enough about music (awareness)	1.68±0.47	1.34±0.48	3.720	0.001**
3	I took music lessons because it was a very interesting thing (attitude).	1.36±0.49	1.18±0.39	2.074	0.044*
4	I am willing to spend some time after class to learn the content of the music course (attitude).	1.75±0.44	1.57±0.50	1.745	0.088
5	If I have a problem with my music course, I will ask the teacher for advice (behavior).	1.89±0.32	1.73±0.45	2.007	0.051
6	After the music course, I will discuss with others what I learned in class (behavior).	1.91±0.29	1.57±0.50	3.720	0.001**

Participants' attitude, behaviour as well as awareness improved after learning with AI. The first item "The only reason I took music classes was because it was part of the curriculum at school (awareness)" however

showed no significant difference, indicating that for either of the traditional and AI learning, the students' opinion did not differ whether learning was traditional or AI-supported.

The positive shift in student attitudes towards music learning with AI is a significant finding. This suggests that AI can make learning more engaging and motivating, leading to increased interest and participation. We therefore accept the alternative hypothesis and conclude that AI software for learning music appreciation will improve student attitudes to vocational music learning.

4.4. Impact of Gender on Students' Attitudes.

Although gender was not captured as a key variable in the study, based on its known impact on creative and affective skills (Nissen & Shemwell, 2016), we examined if gender has any impact on students' attitudes. The results in Table 9 shows that gender has no significant impact on the test scores or overall result (t=1.165, p>0.05).

Table 9 *T-test of gender effect on students' attitudes*

	Gender (Mean value±SD)		t	p
	Female (n=22)	Male (n=22)		
Grade	10.27±2.511	9.45±2.132	1.165	0.251

This finding supports other studies, for example Xia et al. (2022), who found that students' gender had nothing to do with their learning engagement, even though AI can help them improve their learning engagement. This study can provide confirmatory evidence of the impact of both gender and AI software on the improvement of students' attitude to learning.

6. Discussion

The findings from this study provide partial support for the effectiveness of AI software in enhancing specific music appreciation skills among vocational students. While the software improved only 4 out of the 13 indicators of music listening skills, it showed a comprehensive positive effect on music reading skills, fully supporting H02. These results suggest that while AI tools may excel in developing cognitive and visual competencies required for reading music (Ivaldi & O'Brien, 2020), their impact on auditory-focused skills, such as detailed listening, may be limited. This aligns with previous research that indicates AI tools can effectively aid in structured tasks like notation and reading, which involve clear patterns and rule-based recognition (Goussios & Davidson, 2021).

Furthermore, the improvement in student attitudes toward vocational music learning observed in support of H03 aligns with earlier findings on AI's ability to enhance engagement and motivation in educational settings (Brown et al., 2023). This suggests that AI's interactive and adaptive nature may foster a more positive learning environment, encouraging vocational students to explore music in depth and appreciate the learning process.

In contrast, the limited impact on music listening skills could indicate that AI software needs further development to address complex auditory competencies, such as recognizing subtle musical elements. Future research should consider integrating features that allow for more active listening exercises to provide a balanced approach to skill development in music appreciation.

7. Implications of Findings and Future Research Directions

This study is novel in its adoption of a low-cost option that allows students who lack access to ideal learning conditions to improve their learning through AI software. In addition, the study also focus on music listening and reading, which are foundational to music appreciation. Considering that no formal tests have been conducted in music course over the past years, the tests developed in this study covers all the 17 indicators of music listening and reading, and can serve as a foundation for building more robust standard tests for improving vocation music education.

The results show that a combination of AI software and standard teacher-led instruction can improve the performance of students in learning music courses, and contribute to the goal of educational equity and SDG4. Kabudi (2022) noted that teachers' learning AI software in practice can improve their teaching and productivity; this is also confirmed by this study. The result further highlights the potential of AI in addressing the challenges of learners in economically challenged areas.

The findings of the study have several theoretical and practical implications especially for the design and implementation of music education programs.

Multiple areas for future studies are also highlighted by the study including tailored AI interventions, investigating how AI can be effectively integrated with traditional teaching methods to optimize learning

outcomes, longitudinal studies focused on assessing the long-term effects of AI-powered music education on students' musical abilities and career prospects. Others are cross-cultural or comparative studies across different cultural and educational contexts to provide valuable insights into the universal applicability of AI in music education. Studies of mechanisms underlying the effectiveness of AI-supported instruction is also required; it will help to identify the specific aspects of AI-supported instruction that contribute to the observed improvements.

8. Conclusion

This study explores the potential of AI software in supporting vocational music learning. With the help of AI software, learning content for listening and reading skills in music appreciation courses was taught using AI and no AI. The result shows that AI improved students' participation in class and made students' attitude more positive thus influencing students' performance. After learning using AI software, students' overall academic performance improved, thus confirming Chiu (2024)'s submission that AI software can help teachers modify their own teaching with AI software and help students improve their learning performance. AI-supported instruction can be a valuable tool for enhancing music education. It may provide personalized learning experiences, interactive exercises, and immediate feedback, leading to improved student outcomes

The challenges and limitations identified with this study include the short experimental period, and the basic course content. In addition, the impact of AI software on students' learning motivation has not been extensively studied. A larger sample size and a standard experimental design may also improve feedback. In terms of cultural context, the study was conducted in a Chinese vocational school and the findings may not be directly applicable to other cultural and educational contexts. Further related to this limitation is the challenge of software restriction in China which limits access to open-source tools within China. This limitation might also affect the generalizability or comparability of the results with studies in other countries with broader software access.

This study offers a preliminary exploration of the potential of AI in music education. While the findings are encouraging, further research is necessary to fully understand the mechanisms underlying AI's impact and to develop strategies for maximizing its benefits. Overall, the results of this study suggest that AI-supported instruction has the potential to revolutionize music education. Further research is needed to fully understand the benefits and limitations of this approach.

Acknowledgement

Conflict of Interest

Authors declare that there are no conflicts of interest regarding the publication of the paper.

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Ren Jiuzhou, Bosede Iyiade Edwards; **data collection and analysis:** Ren Jiuzhou; **interpretation of results:** Ren Jiuzhou, Bosede Iyiade Edwards; **draft manuscript preparation:** Ren Jiuzhou, Bosede Iyiade Edwards. All authors reviewed the results and approved the final version of the manuscript..*

References

Atkinson, R. C., & Shiffrin, R. M. (1968). Human Memory: A Proposed System and its Control Processes. *Psychology of Learning and Motivation - Advances in Research and Theory*, *2*(C), 89–195. https://doi.org/10.1016/S0079-7421(08)60422-3

Brown, T., Smith, J., & Evans, M. (2023). AI in education: Engagement and motivation in student learning. Journal of Educational Technology, 35(1), 12-23.

Okolocha, C. C. (2016). The Role of Vocational and Vocational and Technical Education(VTE) in Nigerian Democratic Dispensation. *International Journal of Capacity Building in Education and Management (IJCBEM)*, *2*(4), 12–24.

Chen, O., Paas, F., & Sweller, J. (2023). A Cognitive Load Theory Approach to Defining and Measuring Task Complexity Through Element Interactivity. In *Educational Psychology Review* (Vol. 35, Issue 2). https://doi.org/10.1007/s10648-023-09782-w

Chen, Z. (2024). Establishment and Application of Evaluation System for Objective Management of Music and Aesthetic Education Teaching in Colleges and Universities. *Applied Mathematics and Nonlinear Sciences*, *9*(1). https://doi.org/10.2478/amns-2024-0961

Chiu, T. K. F. (2024). A classification tool to foster self-regulated learning with generative artificial intelligence by applying self-determination theory: a case of ChatGPT. *Educational Technology Research and Development*, *72*(4), 2401–2416. https://doi.org/10.1007/s11423-024-10366-w

Clark, R. C., & Mayer, R. E. (2012). e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning: Third Edition. In *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning: Third Edition*. https://doi.org/10.1002/9781118255971

Dai, X. (2024). The Path of Cultivating Music Appreciation Ability in Piano Education in Colleges and Universities in the Internet Era. *Applied Mathematics and Nonlinear Sciences*, *9*(1). https://doi.org/10.2478/amns-2024-0553

Deliyannis, I., Özarslan, Y., Toulis, I., Longo, R., Emmanouil, M., & Mylonas, N. (2024). Navigating Digital Frontiers in Music Education: The MUSENSE Project's Contribution to E-Learning. *European Journal of Contemporary Education and E-Learning*, *2*(2), 57–64. https://doi.org/10.59324/ejceel.2024.2(2).05

Evans, P. (2015). Self-determination theory: An approach to motivation in music education. *Musicae Scientiae*, *19*(1), 65–83. https://doi.org/10.1177/1029864914568044

Feng, Y., & Peng, J. (2024). Transformation of educational introspection: evaluation of the current situation and development of basic music education in China. *Trans/Form/Acao*, *47*(5). https://doi.org/10.1590/0101-3173.2024.v47.n5.e02400169

Goussios, C., & Davidson, J. (2021). Music cognition and AI: Assessing learning tools in music education. Music Learning Review, 27(3), 45-63.

Holland, S. (2000). Artificial Intelligence in Music Education: a critical review. In *Contemporary Music Studies* (Vol. 20). Harwood Academic Publishers. https://www.researchgate.net/publication/228554294

Holster, J. (2024). *Augmenting Music Education Through AI: Practical Applications of ChatGPT*. https://doi.org/10.13140/RG.2.2.35958.57923/1

Huang, Y. (2024). On The Cultivation of Music Aesthetic Quality in Music Appreciation of Teenagers. In *Journal of Education, Humanities and Social Sciences IMPES* (Vol. 2023).

Ivaldi, M., & O'Brien, L. (2020). Reading music with AI support: Cognitive impacts on novice learners. Music Pedagogy Journal, 19(2), 102-119.

Jabarullah, N. H., & Iqbal Hussain, H. (2019). The Effectiveness of Problem-based Learning in Technical and Vocational Education in Malaysia. *Education and Training*, *61*(5), 552–567.

Jing, Y. J., & Keat, O. B. (2024). The Contemporary Development of Music Education in China: A Critical Review. *International Journal of Social Science and Human Research*, *7*(08). https://doi.org/10.47191/ijsshr/v7-i08-55

Kabudi, T. M. (2022). Artificial Intelligence for Quality Education: Successes and Challenges for AI in Meeting SDG4. *IFIP Advances in Information and Communication Technology*, *657 IFIP*, 347–362. https://doi.org/10.1007/978-3-031-19429-0_21

Leahy, W., Hanham, J., & Sweller, J. (2015). High Element Interactivity Information During Problem Solving may Lead to Failure to Obtain the Testing Effect. *Educational Psychology Review*, *27*(2), 291–304. https://doi.org/10.1007/s10648-015-9296-4

Liu, Q., & Pan, H. (2024). Investigation of the Problems of Vocational Education in China. *Lecture Notes in Education Psychology and Public Media*, *34*(1), 134–140. https://doi.org/10.54254/2753-7048/34/20231961

Liu, X. (2023). Trends in Informatization of Electronic Music Composition Data in the Context of Distance Education. *EAI Endorsed Transactions on Scalable Information Systems*, *10*(6). https://doi.org/10.4108/eetsis.3826

MacIntyre, P. D., Schnare, B., & Ross, J. (2018). Self-determination theory and motivation for music. *Psychology of Music*, *46*(5), 699–715. https://doi.org/10.1177/0305735617721637

Milakis, E. D., Argyrakou, C. C., Charalampidis, G., Bampouli, I., & Lalou, A. (2024). Insights from ChatGPT-4: Pioneering AI in Music Education for Young Learners. *Nternational Journal of Humanities and Social Science Invention (IJHSSI)* , *13*(1), 51–61.

Müller, A. (2024). Cooperation Between Colleges and Companies: Vocational Education, Skill Mismatches and China's Turnover Problem. *The China Quarterly*, 1–19. https://doi.org/10.1017/s0305741023001868

Nissen, J. M., & Shemwell, J. T. (2016). Gender, experience, and self-efficacy in introductory physics. *Physical Review Physics Education Research*. https://doi.org/10.1103/PhysRevPhysEducRes.12.020105

Okoye, R., & Arimonu, M. O. (2016). Technical and Vocational Education in Nigeria : issues , challenges and a way forward. *Journal of Education and Practice*, *7*(3), 113–118.

Peters, D., Calvo, R. A., & Ryan, R. M. (2018). Designing for motivation, engagement and wellbeing in digital experience. *Frontiers in Psychology*, *9*(MAY). https://doi.org/10.3389/fpsyg.2018.00797

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, *25*(1). https://doi.org/10.1006/ceps.1999.1020

Shang, M. (2019). The Application of Artificial Intelligence in Music Education. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *11644 LNCS*, 662–668. https://doi.org/10.1007/978-3-030-26969-2_62

Shu Li. (2024). Intelligent Construction of University Music Education Teaching System Based on Artificial Intelligence Technology. *Journal of Electrical System*, *20*, 530–539.

Suwanphithak, W., Ruwicha, C., & Chuppunnarat, Y. (2023). Problems and Expectations of Students Regarding the Management of Learning in the Subjects of Thai Music Theory and History within the Thai Undergraduate Music Education Curriculum. *Malaysian Journal of Music*, *12*(2), 1–17. https://doi.org/10.37134//MJM.VOL12.2.1.2023

Tabbers, H. K., Martens, R. L., & van Merriënboer, J. J. G. (2004). Multimedia instructions and cognitive load theory: effects of modality and cueing. *The British Journal of Educational Psychology*, *74*(Pt 1), 71–81. https://doi.org/10.1348/000709904322848824

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*(6), 1273–1296.

Váradi, J. (2022). A Review of the Literature on the Relationship of Music Education to the Development of Socio-Emotional Learning. *SAGE Open*, *12*(1). https://doi.org/10.1177/21582440211068501

Waddell, G., & Williamon, A. (2019). Technology use and attitudes in music learning. *Frontiers in ICT*, *6*(MAY). https://doi.org/10.3389/fict.2019.00011

Wang, G. (2024). The investigation of artificial intelligence-based applications in music education. *Applied and Computational Engineering*, *36*(1), 210–214. https://doi.org/10.54254/2755-2721/36/20230448

Weilan Zhang. (2024, March 24). China's Moonshot AI fuels domestic large model app frenzy, aiming to overtake ChatGPT. *Global Times*.

Wilunda, C., Quaglio, G., Putoto, G., Lochoro, P., Dall'Oglio, G., Manenti, F., Atzori, A., Lochiam, R. M., Takahashi, R., Mukundwa, A., Oyerinde, K., Wall, L. L., The World Bank, The Mendeley Support Team, Tarekegn, S. M., Lieberman, L. S., Giedraitis, V., Sewunet, Z., Rural, M. of A., … Bekele, A. (2015). Federal Democratic Republic of Ethiopia Ministry of Health. HSTP: Health Sector Transformation Plan (2015/16-2019/20). *Ey & Ficci*. https://doi.org/10.1016/S0022-0248(99)00534-5

Xia, Q., Chiu, T. K. F., Lee, M., Sanusi, I. T., Dai, Y., & Chai, C. S. (2022). A self-determination theory (SDT) design approach for inclusive and diverse artificial intelligence (AI) education. *Computers and Education*, *189*. https://doi.org/10.1016/j.compedu.2022.104582

Yamauchi, L. G. (2008). *Effects of multimedia instructional material on students' learning and their perceptions of the instruction*. 62.

Yingben, C. (2021). *A preliminary exploration on the development of school-based music textbooks for secondary vocational schools based on core literacy-Taking Guangdong Civil Affairs Vocational and Technical School as an example*.

Zhou, N. (2018). *Reflections on Using Music Education to Improve the Comprehensive Quality of Higher Vocational Students*.

Zipse, M. M., Sauer, W. H., Varosy, P. D., Aleong, R. G., Nguyen, D. D. T., Zipse, M. M., Sauer, W. H., Varosy, P. D., Zeb, M., Curzen, N. N., Veldtman, G., Yue, A., Roberts, P. R., Wilson, D. G., Morgan, J. M., Avenue, G., Desk, R., Williams, L., Yancy, C. W., … Iaizzo, P. a. (2014). NIH Public Access. *Heart Rhythm*. https://doi.org/10.1161/CIRCEP.114.003030