What Are the Challenges and Opportunities Presented by Artificial Intelligence in the Field of Vocal Education?

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I. INTRODUCTION

Artificial Intelligence (AI) is a rapidly advancing and promising technology with potential uses in all aspects of our daily lives, including education (Yang and Yang, 2020). One of the many areas of education being infiltrated by Artificial Intelligence is vocal education, but what are the challenges and opportunities presented by Artificial Intelligence in the field of vocal education?

This paper proposes collaboration between AI programmers and skilled vocal educators is essential to fully explore the potential of AI as a way to enhance vocal training and address the challenges and evolving needs of voice lessons in the digital age. I suggest there is a pressing need for research to determine how best to create an ethical and credible space for AI in vocal education (Ovcharenko et al., 2020). In this narrative review, I will examine the current state of Artificial Intelligence, the challenges in current vocal education, the need for AI training for teachers, and the necessity of additional research using AI in vocal education. Furthermore, I will explore how AI could become a viable tool in vocal education, suggest the next steps for its effective and ethical integration, and outline a plan to utilize AI in my practice.

A. Methods

When initially tasked with selecting a research area, I created a mind map to identify what topics might interest me (Appendix A: Mind Map—Topics). While there were several branches on my map, I was most drawn to the technology category. With a Bachelor of Music in Sound Recording Technology and 30 years of experience as a web application developer, integrating my love of singing with my passion for technology has always intrigued me. Researching AI in vocal education seemed like a logical next step in my career journey.

Given the limited research in this emerging field, I have chosen to present my findings as a narrative review. This approach allows for exploration and evaluation of available literature while highlighting gaps in current research and suggesting possible strategies for integrating AI in vocal education (Sarkar and Bhatia, 2021; Sukhera, 2022). With many newer researchers in this area only recently getting published and some foremost experts choosing to write blogs instead of traditional publications, I will incorporate evidence from grey literature including PhD dissertations, conference proceedings, online videos, and websites along with available peer-reviewed literature.

My search strategy for finding literature involved entering keywords in Google Scholar, Google, and the University of Wales Trinity Saint David (UWTSD) online library, then taking an iterative approach to revise and strengthen results (Aromataris and Riitano, 2014). With the selected literature, I used backward snowballing—examining cited papers—and forward snowballing—finding citations of the paper (Jalali and Wohlin, 2012a) (Appendix B: Search Table). My inclusion/exclusion criteria were minimal, but literature needed to pertain to either Artificial Intelligence, education, technology in vocal education, or vocal education (Appendix C: Inclusion/Exclusion Criteria).

For quality appraisal of literature, I considered citation counts, explored articles referenced within the literature, and assessed the author's publication history. Using the CRAAP test (Currency, Relevance, Authority, Accuracy, and Purpose), I ensured information was current, relevant to my topic, and either peer-reviewed or authored by industry experts (Blakeslee, 2004). In this particular topic, there are many new voices in the world of research, so having few citations does not necessarily mean the literature is invalid (Appendix H: Literature Quality Appraisal).

II. WHAT IS AI?

Artificial Intelligence refers to technology allowing computers to simulate human intelligence and problem-solving skills (IBM, 2024). First theorised by Alan Turing in 1950, research into AI gained momentum in the early 2000s when researchers shifted their focus from creating an all-knowing machine to finding specific solutions to specific problems (Lawrence Livermore National Laboratory, 2024). AI processes data quickly, allowing machines to independently generate and store additional data (Shi et al., 2020). Over the past few decades, AI has transformed from simple remote-controlled robots navigating rooms to advanced algorithms that can generate realistic images and understand complex language. (Kuipers et al., 2017).

A. Types of AI

AI can be classified into three categories: Narrow AI, General AI, and Artificial Superintelligence (Khan, 2021). Both General AI (software with comparable cognitive abilities to humans) and Artificial Superintelligence (intellect beyond humans) are purely hypothetical at this time, although both may become a reality several decades from now (Fang et al., 2018).

All currently available forms of AI fall within the Narrow AI category and are designed to perform a specific range of tasks, focusing on one or more specialised areas of functionality such as personal assistants (Alexa, Siri, and ChatGPT), Google's search engine, writing tools such as Grammarly, self-driving automobiles, and facial recognition systems (Fang et al., 2018; Keita, 2023) (Appendix D: Types of Artificial Intelligence).

B. AI Issues

Communicating with AI requires computers to converse with humans using natural languages such as English and Spanish, primarily in the form of a prompt—an initial question or instruction given to AI to generate a response or perform a task (Fang et al., 2018). One issue with AI is designing effective prompts often requires multiple revisions to create an exact prompt that generates an acceptable answer (Bauer, 2023; Zamfirescu-Pereira et al., 2023). While prompt design tools are available, they are geared toward natural language processing (NLP) experts rather than general users (Zamfirescu-Pereira et al., 2023).

Another issue, hallucinations, is generally caused by incomplete or biased data provided to the AI model (Bauer, 2023), resulting in inaccurate or misleading responses to user prompts. Bias occurs when an AI model is trained on incomplete data, resulting in either missing or insufficiently diverse information to produce accurate responses (Huriye, 2023). For example, when asked, "How do I shake my voice?" ChatGPT responded with a confusing recommendation (The Fairy Voice Mother, 2023).

To create a vibrato effect in your voice:

1. Start with a sustained note.
2. Gently shake your larynx (voice box) and the surrounding muscles.
3. Keep the pitch steady while allowing the vibration to occur.
4. Experiment with the speed and depth of the vibration until you achieve sound.
5. Practice regularly to develop control and consistency in your vibrato.

Figure 1: ChatGPT Response (The Fairy Voice Mother, 2023)

Laryngeal manipulation, while a recognised vocal therapy, requires proper training and is not used to create vibrato (Garabet et al., 2024). Vibrato is an internal process primarily caused by oscillation of vocal fold length (Lester-Smith et al., 2024). I submit a singer would be ill-advised to follow this recommendation from AI.

Another potential issue involves privacy and data protection (Konidena et al., 2024). With any AI application, personal data may be collected potentially causing a risk if data falls into the wrong hands, making it important AI developers take appropriate measures to prevent data breaches (Harry, 2023).

One of the most critical issues with AI is its sizeable carbon footprint (Alzoubi and Mishra, 2024). During training, AI uses a significant amount of energy to power its machines, but the constant generation of new data requires ongoing training of the AI model, resulting in a nonstop usage of energy resources (Castro, 2024). One AI model in linguistics produces over 284 tons of carbon dioxide, which is comparable to five times the total emissions generated by an average American car over its lifetime (Brevini, 2020; Strubell et al., 2019). As such, corporations including Google and Microsoft are exploring green AI with preliminary case studies showing carbon footprint reductions by up to 30% through optimising algorithms or using renewable energy sources (Alzoubi and Mishra, 2024).

III. VOCAL EDUCATION

While vocal pedagogy has evolved over the last few decades due to advances in vocal science, vocal education still relies primarily on traditional methods of private in-person instruction (Yang and Yang, 2020), often using curriculum that ignores the diverse needs and abilities of students (Fu, 2020).

A. Accessibility

One issue is that quality voice lessons are often inaccessible due to prohibitive costs of private teachers, geographical barriers particularly in remote or underserved areas, and scheduling conflicts with personal commitments like work, school, and family (Digitrax.AI, 2024; Yang and Yang, 2020). Many vocal enthusiasts are turning to online YouTube educators for instruction, but without feedback and guidance, students may foster misconceptions about what comprises

correct vocal production (Marks, 2013). Accessibility issues may serve as a barrier for aspiring singers, either leading to inconsistent participation, insufficient instruction, or preventing them from seeking vocal instruction entirely (Digitrax.AI, 2024).

B. Abstract Concepts

Another challenge in vocal education is that singers must learn to control their vocal apparatus without being able to see it directly (Bowes, 2009). Voice teachers often use abstract concepts, imagery, and analogies, both verbally and kinetically, to convey technique (Ekholm et al., 1998; Kar, 2021). However, this can be confusing for students, highlighting the need for more tangible forms of teaching vocal techniques (Bartlett, 2014). While there are standard items that form what is considered correct and pleasant-sounding singing such as articulation, resonance, and adequate breath support, it is important to note not all students approach learning similarly (Han, 2022). Additionally, guidance may differ depending on a person's culture or experiences, as people understand vocal concepts better when using familiar ideas and risk severe vocal problems if misunderstood or misapplied (Doğanyiğit and Yiğit, 2023).

In summary, while vocal education has a rich tradition, it faces challenges calling for innovative solutions to make it more effective and widely accessible (Ovcharenko et al., 2020).

IV. AI AS A SOLUTION

A. Accessibility

AI voice applications can provide a solution to several challenges in vocal education, including cost, geographical limitations, and time constraints (de Haas, 2023). Firstly, they offer a cost-effective alternative to private lessons while still providing personalised, quantifiable feedback (Digitrax.AI, 2024). Secondly, with global internet availability, many students who cannot access in-person lessons can overcome geographical limitations by benefitting from AI programs (de Haas, 2023). Thirdly, with on-demand learning, AI voice lessons alleviate time constraints by offering unlimited access to instruction anytime (Yang and Yang, 2020). In summary, by using innovative technologies like Artificial Intelligence, access to vocal training can be extended to millions of students who do not have access to music education (de Haas, 2023).

B. Visualization

Experts agree imagery in vocal education can significantly improve the voice by affecting involuntary muscles and helping to concretise abstract concepts (Doğanyiğit and Yiğit, 2023). However, research has shown a combination of approaches provides the best outcomes to since learners have different learning methodologies (Jestley, 2011). Similarly, while subjective evaluation has its merits, achieving an objective and practical assessment from a human voice teacher can be challenging due to influences from their own skill level, teaching strategies and physical and emotional state (Cao, 2022; Yuan, 2024). Real-time visual feedback using an AI model in vocal education can transform abstract content into visual images, guiding students in correcting vocal technique making assessments based on quantitative analysis rather than subjective criteria, with or without a human teacher's involvement (Wang and Zhang, 2022).

In a case study published by Doğanyiğit and Islim (2021), virtual reality (VR) was used in the vocal training of eight music students at a fine arts facility. The study focused on creating interactive visualisations for students using a 360-degree view of a roller coaster, which varied speed and amplitude in inverse relation to high and low pitches. With VR visualisation making abstract thoughts more tangible, students reported more comfortable vocal production of higher pitches, decreased stress on the larynx, and found it easier to open up resonance gaps at upper levels. The majority of participants noticed improvement in breath control, and all participants felt VR was useful for vocal education. While this application was by no means a replacement for a human teacher's guidance, it offered additional support for students' education (Doğanyiğit and Islim, 2021).

C. Teaching with AI

Artificial intelligence has firmly established itself in the world of education, bringing with it fears of reducing or even losing jobs (Nur Fitria, 2023). While AI's role in vocal education has undeniable benefits, it is not without its challenges still and cannot replace voice teachers entirely (Han, 2022).

AI can provide objective feedback on technical aspects, but capturing emotional nuances and expressiveness often crucial to a performance is a complex task (Nur Fitria, 2023). A teacher's role in vocal education goes beyond teaching technique and addressing vocal limitations; the

teacher is also there to help mitigate other challenges, including a student's preconceptions about singing, self-esteem, emotional pressures, and confidence (Marks, 2013).

Rather than replace a human teacher, AI could serve as a supportive tool, enhancing human efforts and offering a richer learning experience for aspiring singers (Yang and Yang, 2020). Modern voice training stands to benefit from integrating traditional and innovative methods (Han, 2022). It is crucial to explore how to leverage this technology best to expand opportunities in the world of singing, both as educators and as students (Caldera, 2024).

In a 2022 study, Han examined the potential effect of mobile applications on vocal education. The study involved 180 students from three universities, divided into three groups. Group A received traditional in-person classical voice training, while Groups B and C used the mobile applications Swiftscares Vocal Trainer and Vox Tools: Learn to Sing, respectively, along with in-person training. Both mobile applications can be programmed with custom exercises from vocal teachers. At the end of the five-month study, students were evaluated on pitch accuracy, breath control, and vocal range. Although there were variations between the second and fourth-year students, those who used a mobile application (Groups B and C) scored higher than those who did not have access to those applications (Group A) (Han, 2022).

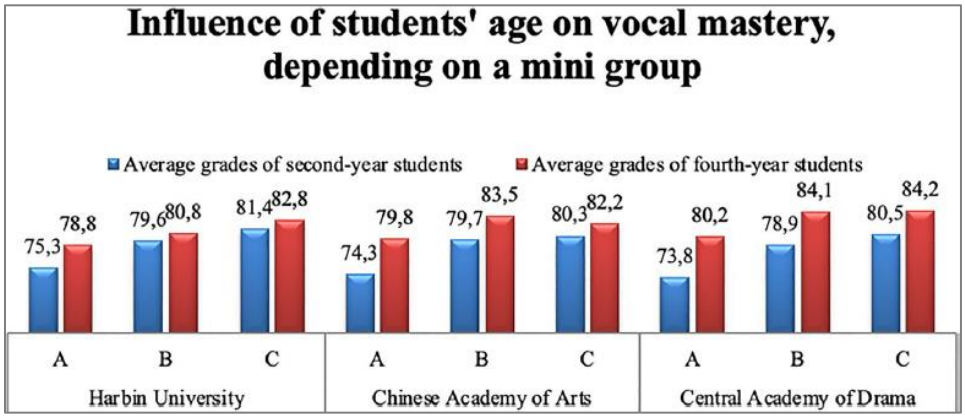

Figure 2: Mobile Application Study Results (Han, 2022)

By using the foundation of these and other studies on using technology in vocal education, it can be posited that a similar effect could be achieved by using an AI-driven application in combination with in-person voice training.

V. NEXT STEPS

To make AI an effective tool in vocal education, I suggest several steps are needed. The ideal situation would be a partnership between vocal educators and AI, but also allow for those in underserved communities to have access to credible training through online vocal programs supported by AI. This could help democratize access to vocal education, while maintaining a role for educators to work with dedicated students.

A. Training

Teachers' varying comfort levels with technology can lead to skepticism about using AI, resulting in hesitance to adopt technology (Woodruff et al., 2023, p. 10; Walter, 2024). Ethical concerns, such as information accuracy, data biases, privacy, job market impact, education quality, and intellectual property rights, have been raised by teachers regarding AI tools like chatbots and ChatGPT (Adiguzel et al., 2023). In order to convince voice educators of AI's effectiveness in teaching, teachers first need to understand the legal, ethical, and technical complexities (Abdikhakimov, 2023).

In a study by Uzumcu and Acilmis (2024), preservice teachers received three AI-driven music tools to use for teaching and assessing students. A word cloud was created using the repeated expressions and themes stated by participants. Prior to the study, the word Robot was heavily documented along with words like technology, computer, logic, coding, and innovation (Figure 3: Pre-study Word Cloud). Post study, words such as technology and computer were more prevalent (Figure 4: Post-study Word Cloud). The most striking item is the appearance of the word ease frequently since teachers had a better understanding of how AI functions, demonstrating a shift in the perception of AI after having hands-on experience and a better understanding of the technology's capabilities (Uzumcu and Acilmis, 2024).

Figure 3: Pre-study Word Cloud (Uzumcu and Acilmis, 2024)

Figure 4: Post-study Word Cloud (Uzumcu and Acilmis, 2024)

B. Research

Since there have been limited studies completed to date, I submit further research needs to be conducted by interdisciplinary teams comprised of AI programmers, voice scientists, and voice educators in order to determine the long-term effects of using the technology (Bauer, 2023). It is crucial to employ collaboration among different stakeholders, making sure that AI models are developed in a way that aligns with expectations and meets the needs of users (Huriye, 2023). Additionally, research has yet to examine the effects of mobile devices or AI in voice education long term and on a broader scale (Han, 2022). I posit that research should be conducted to determine the challenges and opportunities presented by using AI in vocal education both as a stand-alone method and as a synergistic element with a human vocal teacher.

VI. IMPLEMENTATION STRATEGY

While limited, existing studies demonstrate the benefits students could gain from using computer-based vocal education to receive real-time, actionable feedback. Based on these findings, I submit AI-based applications would yield similar results.

Initially, AI could be used to track a student's practice time between lessons with a vocal educator and provide feedback on the accuracy of vocal exercises. Over time, this could expand to adjudicating repertoire. Real-time auditory and visual feedback allows students with different learning styles to make targeted corrections with clear direction on how to improve, and, despite current limitations in perceiving human emotion, AI can infer emotions from intonation, rhythm, and smoothness (Chen, 2022).The training data should be carefully planned by an interdisciplinary team of vocal educators and scientists prior to training the model, minimizing the potential for bias and hallucinations (Ovcharenko et al., 2020). As the AI model becomes more robust, a virtual vocal coach could offer personalised learning without a human voice teacher’s oversight, recommending repertoire and vocal exercises to address specific weaknesses that the AI model identifies (Yang and Yang, 2020).

I have considered multiple technological approaches could be taken to create an AI-based application for vocal education. AI voice teachers can evaluate singing based on prosodic attributes (intonation, vibrato, rhythm, and volume) and articulation attributes (lyrics or phonetic patterns) by comparing these to stored data, music templates, and MIDI files (Chen, 2022). Researchers could also explore sound analysis techniques, AI algorithms, and vocal methodologies to develop a comprehensive means of evaluating singing (Huang, 2024).

There is one strategy, in particular, I theorize could be incredibly effective as part of an AI application in voice education. Real-time feedback technologies, such as spectrographic displays, have been used increasingly by singing teachers since the 1970s and can help analyse intonation, register breaks, vocal onset, vowel modification, and vocal timbre (Lã and Fiuza, 2022). Few vocal educators, let alone their students, know how to correctly interpret spectrograms to utilise this remarkably powerful technology (Ovcharenko et al., 2020). My hypothesis is that integrating AI with spectrograms to read and interpret spectrographic data could be a powerful tool for both students and teachers utilizing the principles of vocal acoustics. I propose this is an area of research worth investigating as an initial step towards

integrating vocal education with AI while maintaining the integrity of vocal pedagogy under the guidance of voice experts (Appendix E: Implementation Strategy).

In my own practice, I plan to experiment with spectrographic data using VoceVista as an application. As such, I intend to spend time learning more about vocal acoustics and VoceVista. I will also spend time as learning about developing AI models in order to create a skeleton of an application for testing purposes (Appendix F: Personal Development Plan).

VII. CONCLUSION

AI is emerging as a valuable tool in vocal education with potential to expand opportunities for both educators and students and initial research has shown that, when combined with traditional one-on-one voice lessons, it can update approaches to voice education while honouring traditional methodologies (Han, 2022). Although an AI voice teacher could increase access to vocal education, the best outcome would still be to combine AI with a human vocal instructor for a comprehensive educational experience (Nur Fitria, 2023). However, input from voice professionals and AI specialists is crucial to AI's success in vocal education, both in ensuring it has access to quality training data and in guiding its appropriate uses and ethical considerations (Bauer, 2023; Woodruff et al., 2023, p.20). Further research across larger and more diverse populations is needed to understand the potential long-term effects of using AI in vocal education on a wider scale (Ovcharenko et al., 2020). Most importantly, teachers need training on AI development, ethical considerations, and best practices to demystify the technology and encourage its use (Walter, 2024; UMass Lowell Magazine Staff, 2024). I propose targeted research with input from voice teachers and scientists, along with comprehensive educator training, as the best path to AI acceptance in vocal education. I further posit that integrating AI with spectrographic data could be a viable tool for both vocal educators and students.

In closing, as a final opinion on whether Artificial Intelligence can serve as an effective and practicable tool for voice training, the foremost expert on the subject was consulted—AI (ChatGate.AI, 2024). Its response:

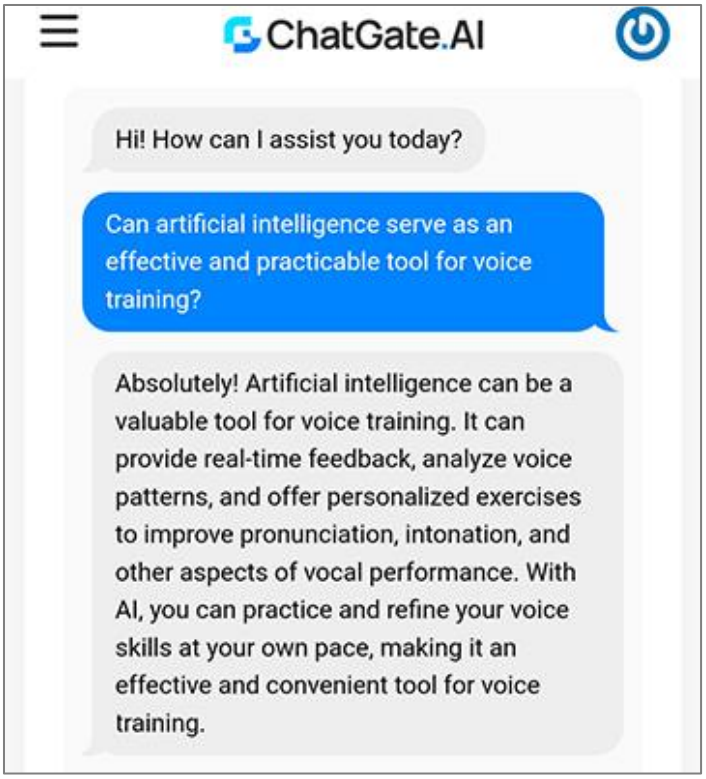

Figure 5: ChatGate.AI Response (ChatGate.AI, 2024)

VIII. REFLECTIVE MODEL

In selecting a reflective learning model for my research, I struggled to find one that truly aligned with my needs. Like others in software development, I find reflective learning challenging likely because troubleshooting is an ongoing part of coding, rather than a distinct process. Schön's model of reflection is often used by software engineers due to its simplicity with focus on reflection in action, encouraging adjustments in real time, and reflection on action, analysing outcomes after project completion (Prior et al., 2016). While Schön's model presents that doing and thinking are complementary (Schön, 1987, p. 280), I prefer to separate these two concepts, believing to accurately reflect on doing, the thinker must temporarily remove themselves from the process to objectively assess their actions and uncover issues.

Conversely, while Gibbs' cycle aligned more with my needs, two of its six criteria—feelings, which did not resonate due to the study's focus on things rather than people, and evaluation, which seemed redundant to analysis—did not fit my thinking process; however, description, analysis, conclusion, and action plan did (Gibbs, 1988).

In application development, I have used Agile methods of project management. Agile's iterative process with continuous revisions complements Gibbs' model by offering additional insight for reflection, particularly through iterative updates (Jalali and Wohlin, 2012b). I also wanted a way to identify related issues to uncover possible solutions. Consequently, I developed my own reflective model combining aspects of Gibbs with Agile, consisting of six criteria: thought, analysis, solutions, knowledge plan, updates, and tracking (Appendix G: Reflective Model).

A. Reflections on Learning

Throughout my learning journey, I have often felt uneasy about writing research papers. Applying my reflective model, the thought was a constant uncertainty as to whether I was doing this correctly. In analysing the issue, I realized I had not written a research paper in 30 years. A lot has changed since then—research used to involve spending hours in the library, photocopying documents, and searching for articles on microfiche. Now, information is available online and I can write and store my research on my personal computer for easy access. The clear solution was to study resources on modern research practices. The knowledge plan included reviewing the UWTSD library info skills tutorial and researching reference management software to use, ultimately deciding to use Zotero to store my literature and annotations.

Since beginning my master’s degree in Vocal Pedagogy, I've been troubled that I spend little time singing. Applying my learning model, I acknowledged the thought that I want to sing more and continue to hone my craft. Through analysis, I realized that given my chosen area of research, this program is unlikely to encourage daily singing. As a solution, I decided to explore online vocal courses that could enhance my vocal skills and possibly integrate with my research. Having recently watched a course by John Henny through the Voice Study Centre (VSC), my knowledge plan is to register for Henny’s voice school to learn new skills and use his online group for accountability and motivation.

As part of the research process, I found reflective learning to be particularly confusing. I applied my learning model to address the thought of how to keep an effective learning journal. I analyzed the issue, citing my lack of experience with learning models as the core issue. I decided the solution was to clarify the process by reading literature pertaining to reflective practices. I discovered many in software development find reflective learning challenging, and one suggestion was to start by asking simple questions to help organize thoughts before

applying a learning model then using a reflective model to structure entries in the learning journal (Gibbs, 1988, p. 54; Prior et al., 2016). I found this strategy, combined with my reflective model, provided enough of a structure to begin keeping a practical learning journal to support my ongoing research.

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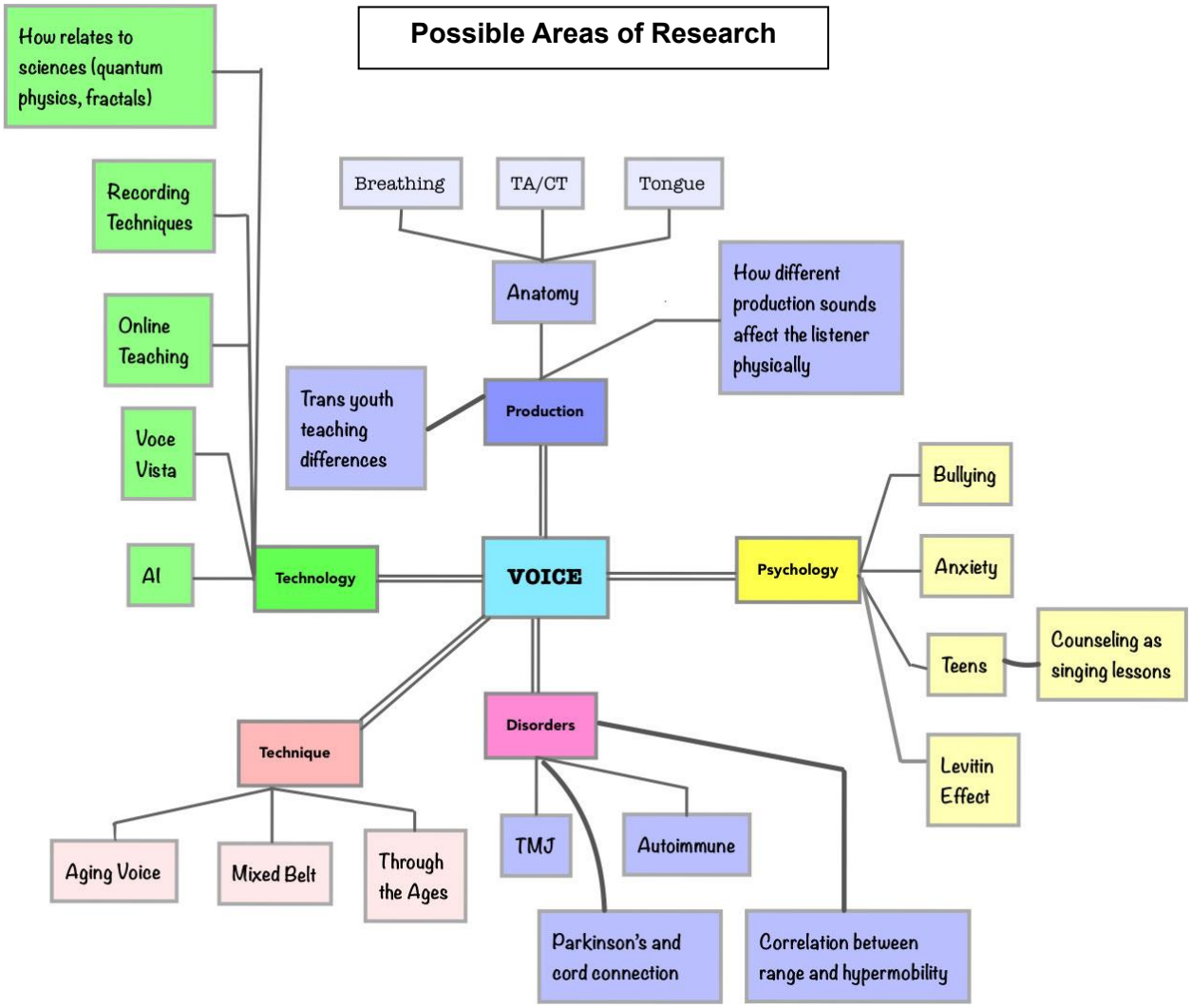
APPENDIX A: Mind Map—Topics



APPENDIX B: Search Table

Topic	Database	Search Terms
AI in education	▪Google ▪Google Scholar ▪UWTSD library Database	▪AI in education +hesitancy to use
AI in vocal education	▪Google ▪Google Scholar ▪UWTSD library Database	▪AI in vocal education +hesitancy to use ▪AI in voice teaching ▪AI teaching singing ▪AI voice teacher
AI in music education	▪Google ▪Google Scholar ▪UWTSD library Database	▪AI in music education >2023 +hesitancy to use
Artificial Intelligence	▪Google ▪Google Scholar ▪UWTSD library Database	▪AI earliest remote controlled ▪AI prompts ▪Artificial Intelligence +categories > 2023 +categories weak strong +energy usage +environmental +ethics +general +green +intellectual property +music education +narrow +prompt issues +singing +types +vocal education ▪Shakey the robot
Literature evaluation	▪Google ▪Google Scholar ▪UWTSD library Database	▪CRAAP test
Literature reviews	▪Google ▪Google Scholar ▪UWTSD library Database	▪Literature process review +Commentary +Types ▪Narrative literature review
Reflective models	▪Google ▪Google Scholar ▪UWTSD library Database	▪Agile project management +Scrum ▪Reflective model +Agile +Driscoll +For education-based software +Gibbs +Schön

Topic	Database	Search Terms
Search strategies	▪Google ▪Google Scholar ▪UWTSD library Database	▪Snowballing +Backward +Forward
Technology in vocal education	▪Google ▪Google Scholar ▪UWTSD library Database	▪Software +music education +singing +vocal education
Vocal education	▪Google ▪Google Scholar ▪UWTSD library Database	▪Singing and vibrato ▪Vocal education +Imagery +Online +Subjectivity +Visualization > 2020 ▪Voice science vibrato > 2023 ▪Vocal visualization in singing education

APPENDIX C: Inclusion/Exclusion Criteria

• Include grey literature such as websites, blogs, conference proceedings, reports, editorials, podcasts, PhD dissertations, and videos.*
• Prioritize peer-reviewed literature.
• Prioritize most recent dates, but include all available research.
• Include literature that addresses both positive and negative aspects of using AI.
• Include all literature about AI, software, mobile applications, and VR related to vocal education.
• Use CRAAP for evaluations of literature.
• Include all studies regardless of number of participants.

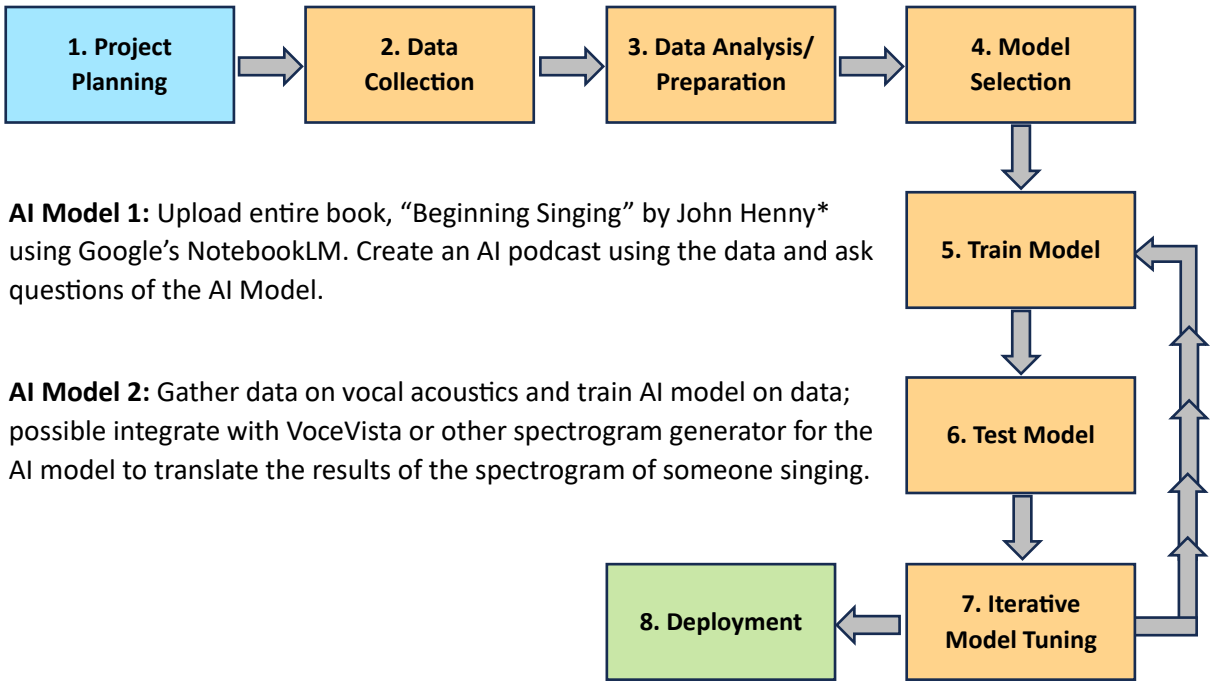
*Many newer researchers in this area are only recently getting published. Additionally, some foremost experts write blogs rather than traditional publications.

APPENDIX D: Types of Artificial Intelligence

	Artificial Narrow Intelligence	**Artificial General Intelligence**	**Artificial Superintelligence**
Description	Machine learning	Machine intelligence	Machine consciousness
Compared to Humans	Not as smart as a human.	As smart as a human.	Smarter than any human.
Limitations	-Simple algorithms. -Goal oriented. -Created to perform a single task.	-Complex algorithms. -Computer can reason and solve problems on its own.	No limitations.
Learning Capabilities	Trained on large quantities of data for deep learning.	Able to learn, think, and understand in order to solve problems.	No limitations.
Decision-making skills	Appears to be making decisions, but it is just advanced computer programming.	Can perform different tasks based on different situations similar to a human.	No limitations.
Self-awareness	Does not have a mind of its own and is not self-aware.	Exhibits strong cognitive behaviour including common sense and is self-aware.	Fully self-aware and autonomous.
Programming	Processes data using NLP (Natural Language Processing) and machine learning.	Uses advanced versions of NLP (Natural Language Processing), machine learning, and neural networks.	Will likely self-evolve from Artificial General Intelligence.
Examples	-Virtual Assistants (Siri, Alexa, Cortana) -Google Search -Netflix recommendations	Hypothetical, but we are proceeding towards it (estimated to become real around 2040).	Hypothetical such HAL 9000 (“2001: A Space Odessey”) and C3PO (“Star Wars”)

(ISIEINDIA, 2024; Khan, 2021; RevolveAI, 2024)

APPENDIX E: Implementation Strategy



AI Model 1: Upload entire book, "Beginning Singing" by John Henny* using Google's NotebookLM. Create an AI podcast using the data and ask questions of the AI Model.

AI Model 2: Gather data on vocal acoustics and train AI model on data; possible integrate with VoceVista or other spectrogram generator for the AI model to translate the results of the spectrogram of someone singing.

1. Project Planning: Using information from this research paper to create a strategy for creating an AI application.

2. Data Collection: Gathering data to analyse vocal performances.

3. Data Analysis/Preparation: Ensuring data is clean and streamlined for training the AI model.

4. Model Selection: Select one of the many models available online for creating the application.

5. Train Model: Load the collected data into the AI model.

6. Test Model: Ensure that the model is responding as expected.

7. Iterative Model Tuning: Revise training data, adding more or removing items as needed to get accurate responses from the AI model. This is iterative, as needed.

8. Deployment: Allow others to use the AI model.

*On his podcast, "Episode 389: Learning to Sing with AI," John Henny gave permission for anyone to upload his book to AI (Henny, 2024).

APPENDIX F: Professional Development Plan

SUBJECT AREA	Thought	Analysis
Tracking: M1.20240926.001 **Item:** Vocal Acoustics **Target Completion Date:** End of Module 3	What can AI use to evaluate vocal performance consistently and universally?	Given that AI does not have opinions, data is needed to train the AI model to consistently evaluate students and give objective, real-time feedback. Uploading another educator's pedagogical theory without their approval is ethically questionable.
	Solutions	**Knowledge Plan**
#vocalacoustics #AI #evaluation #realtime #vocevista	• Train the AI model in a number of different pedagogical methods. Entire books can be uploaded as training data. • Train the AI model to interpret spectrogram data and instruct a user based on that analysis.	☐ Learn VoceVista ☐ Read "Resonance in Singing" by Dr. Donald Gray Miller (if I can obtain a copy) ☐ Read "Practical Vocal Acoustics" by Kenneth Bozeman ☐ Take "Acoustic Vocal Pedagogy" by Kenneth Bozeman course on VSC.

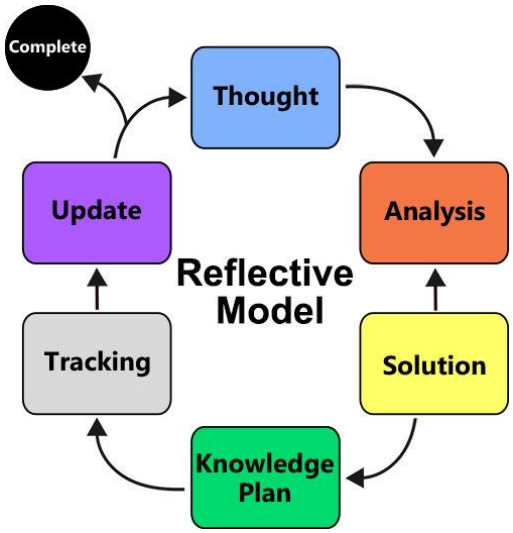
SUBJECT AREA	Thought	Analysis
Tracking: M1.20240926.005 **Item:** General Education **Target Completion Date:** Ongoing	I want to bring the latest techniques and research in vocal pedagogy to my students.	While I only teach a handful of students, I want to ensure they are receiving the most current information on pedagogy, techniques, and voice science.
	Solutions	**Knowledge Plan**
#pedagogy #teaching #VSC	• VSC has a plethora of courses available.	☐ Commit to watching or attending at least one VSC short course each month for the duration of my studies.

SUBJECT AREA	Thought	Analysis
Tracking: M1.20240926.003 **Item:** Building an AI Application **Target Completion Date:** End of Module 6	I am experienced in multiple programming languages, but how is an AI application built?	Considering AI in vocal education as my primary area of research, it is important that I have a better understanding of AI application development so as to be able lead conversations on how best to implement AI as a strategy.
	Solutions	**Knowledge Plan**
#AImodels #AI #programming	• There are many free resources for learning AI. • Experiment with an AI model. • Examine AI-based learning applications.	**Read the following**: ☐ https://appinventiv.com/ ☐ https://www.deeplearning.ai/ ☐ https://www.netsolutions.com/ ☐ https://vercel.com/ ☐ https://ai.google.dev/ **Take this free online course:** ☐ Harvard University CS50s

APPENDIX G: Reflective Model

Based on Gibbs Reflective Cycle (Gibbs, 1988)
and Agile Project Management (Azanha et al., 2017)

Thought
The issue, thought, question, or hypothesis that needs to be addressed.
Analysis
• Why is this an issue? • What was the evolution of the issue? • Evaluate. What are the implications of this?
Solutions
• Brainstorm all possible solutions and alternatives, listing their pros and cons where applicable. • List ideas for improvement. *Not all solutions need to be feasible, but may help evolve other solutions.
Knowledge Plan
• Outline an implementation strategy. • What needs to be done and when. • Create a plan of action including timeline for completion and a quantifiable means for knowing the issue is closed.
Tracking
• Assign a tracking code, category, and/or tags to the item to be easily searchable and to be able to link similar thoughts together and look for patterns, connections, cross-solutions.
Update
• Provide a dated status update on this reflection. • What helped or hindered achieving the completion of the issue? • Is a new knowledge plan needed or is this item closed?



APPENDIX H: Inclusion/Exclusion Criteria

LITERATURE	TYPE	YEAR	CITATIONS	SEARCH TERMS	DATABASE	PEER REVIEWED	TIMES CITED
Abdikhakimov, I. (2023) 'Unraveling the Copyright Conundrum: Exploring AI-Generated Content and its Implications for Intellectual Property Rights', International Conference on Legal Sciences, 1(5), pp. 18–32. Available at: https://www.science-zone.org/index.php/conference/article/view/42.	Conference Paper	2023	0	AI intellectual rights ethics	Google	Y	1
Adiguzel, T., Kaya, M. H., and Cansu, F. K. (2023) 'Revolutionizing education with AI: Exploring the transformative potential of ChatGPT', Contemporary Educational Technology, 15(3), ep429. Available at: https://doi.org/10.30935/cedtech/13152.	Journal Article	2023	38	NA	Snowballing	Y	1
Alzoubi, Y.I. and Mishra, A. (2024) 'Green artificial intelligence initiatives: Potentials and challenges. Journal of Cleaner Production, 468, pp.1-25. Available at: https://doi.org/10.1016/j.jclepro.2024.143090	Journal Article	2024	0	Green Artificial Intelligence	Google Scholar	Y	2
Aromataris, E. and Riitano, D. (2014) 'SYSTEMATIC REVIEWS, Step by Step: Constructing a Search Strategy and Searching for Evidence', The American Journal of Nursing, 114(5), pp. 49–56. Available at: http://www.jstor.org/stable/24466512.	Journal Article	2014	0	research paper search strategy	UWTSD Database	Y	1
Azanha, A., Argoud, A.R.T.T., Camargo Junior, J.B.D., and Antoniolli, P.D. (2017) 'Agile project management with Scrum: A case study of a Brazilian pharmaceutical company IT project', International Journal of Managing Projects in Business. 10(1), pp. 121–142. Available at: https://doi.org/10.1108/IJMPB-06-2016-0054.	Journal Article	2017	53	agile project management	Google Scholar	Y	1
Bartlett, I. (2014) 'Reflections on contemporary commercial singing: an insider's perspective', Voice and Speech Review, 8(1), pp. 27–35. Available at: https://doi.org/10.1080/23268263.2013.829711.	Journal Article	2014	10	NA	Snowballing	Y	1
Bauer, W.L. (2023) Make AI Your Personal Music Teaching Assistant: 4 ideas you can use now! Available at: https://musiceducation.arts.ufl.edu/resources/ai-music-teaching-assistant/ (Accessed: 7 May 2024).	Website	2023	NA	artificial intelligence vocal education	Google	Grey Literature	4
Blakeslee, S. (2004) 'The CRAAP Test', LOEX Quarterly, 31(3), pp. 6-7. Available at: https://commons.emich.edu/loexquarterly/vol31/iss3/4	Journal Article	2004	287	CRAAP test	Google	Y	1
Bowes, P.L. (2009) An Exploratory Study of the Use of Imagery by Vocal Professionals: Applications of a Sport Psychology Framework. PhD thesis. University of South Florida. Available at: https://www.semanticscholar.org/paper/An-Exploratory-Study-of-the-Use-of-Imagery-by-Vocal-Bowes/5291eeb1321eb97c025b144a36af959f5ba2f35a. (Accessed: 3 October 2024).	PhD Thesis	2009	1	visualization vocal education	Google Scholar	Grey Literature	1
Brevini B. and Murdock G. (2017) *Carbon Capitalism and Communication: Confronting Climate Crisis* . London: Palgrave Macmillan.	Book	2017	NA	artificial intelligence environment issues	Google	Book	1

LITERATURE	TYPE	YEAR	CITATIONS	SEARCH TERMS	DATABASE	PEER REVIEWED	TIMES CITED
Caldera, T. and Vidanage, K. (2024) 'AI-Driven Voice Training and Singing Improvement: A Comprehensive Literature Review', 4th Student Symposium Faculty of Computing, General Sir John Kotelawala Defence University, Sri Lanka, January 2024. Proceedings of the 4th Student Symposium Faculty of Computing. Available at: https://www.researchgate.net/publication/378898885_AI-. (Accessed: 3 October 2024).	Conference Paper	2024	0	artificial intellegence in vocal education	Google	Y	1
Cao, W. (2022) 'Evaluating the Vocal Music Teaching Using Backpropagation Neural Network', *Mobile Information Systems,* 2022, pp. 1-7. Available at: https://doi.org/10.1155/2022/3843726.	Journal Article	2022	0	artificial intellegence in vocal education	Google	Y	1
Castro, D. (2024) 'Rethinking Concerns About AI's Energy Use' Center for Data Innovation, January 2024. Available at: https://datainnovation.org/2024/01/rethinking-concerns-about-ais-energy-use/.	Report	2024		artificial intelligence energy	Google	Grey Literature	1
ChatGate.AI (2024) ChatGate.AI response to Wende Donahue, 21 June.	Chat GPT	2024	NA	NA	NA	Grey Literature	2
Chen, W. (2022) 'Design of Music Teaching System Based on Artificial Intelligence', Mathematical Problems in Engineering, 2022, pp. 1–7. Available at: https://doi.org/10.1155/2022/2627395.	Journal Article	2022	0	artificial intelligence in music education	Google Scholar	Y	2
de Haas, B. (2023) How AI is Reshaping Music Education. Available at: https://www.unite.ai/how-ai-is-reshaping-music-education/ (Accessed: 10 May 2024).	Website	2023	NA	artificial intelligence in voice education	Google	Grey Literature	3
Digitex (2024) Accessible Singing Education: The Role of AI Voice Clones. Available at: https://www.linkedin.com/pulse/accessible-singing-education-role-ai-voice-clones-digitrax-ai-5l4de (Accessed: 14 May 2024).	Website	2024	NA	artificial intelligence in voice education	Google	Grey Literature	2
Doğanyiğit, S., Islim, O.F. (2021) 'Virtual reality in vocal training: a case study', Music Education Research, 23(3), pp. 391–401. Available at: https://doi.org/10.1080/14613808.2021.1879035.	Journal Article	2021	0	technology in vocal education	Google Scholar	Y	4
Doğanyiğit, S. and Yiğit, N. (2023) 'The perspective of trainers on the use of imagination in singing training', Journal of Pedagogical Research, 7(1), pp. 174-186. Available at: https://doi.org/10.33902/JPR.202317864.	Journal Article	2023	0	vocal education imagery	Google Scholar	Y	2
Ekholm, E., Papagiannis, G.C., and Chagnon, F.P. (1998) 'Relating objective measurements to expert evaluation of voice quality in western classical singing: Critical perceptual parameters', Journal of Voice, 12(2), pp. 182–196. Available at: https://doi.org/10.1016/S0892-1997(98)80038-6.	Journal Article	1998	86	subjective in vocal education	Google Scholar	Y	1
Fang, J., Su, H. and Xiao, Y. (2018) *Will Artificial Intelligence Surpass Human Intelligence?* Unpublished. Available at: http://dx.doi.org/10.2139/ssrn.3173876.	Journal Article	2018	6	AI Categories weak strong >2023	Google Scholar	Y	3
Fu, L. (2020) 'Research on the Reform and Innovation of Vocal Music Teaching in Colleges', Region -Educational Research and Reviews, 2(4), pp. 37-40. Available at: https://doi.org/10.32629/rerr.v2i4.202.	Journal Article	2020	10	NA	Snowballing	Y	1

LITERATURE	TYPE	YEAR	CITATIONS	SEARCH TERMS	DATABASE	PEER REVIEWED	TIMES CITED
Garabet, R., Melley, L.E., and Sataloff, R.T. (2024) 'Noninvasive Management of Voice Disorders: An Umbrella Review', Journal of Voice [Preprint]. Available at: https://doi.org/10.1016/j.jvoice.2024.03.027.	Journal Article	2024	0	vibrato in singing	UWTSD Database	Y	1
Gibbs, G. (1988) *Learning by Doing, A Guide to Teaching and Learning Methods.* Oxford Centre for Staff and Learning Development.	Book	1988	807	Gibbs reflective model	Google Scholar	Y	2
Han, X. (2022) 'Design of Vocal Music Education System Based on VR Technology' Procedia Computer Science, 7th International Conference on Intelligent, Interactive Systems and Applications ISSN 1877-0509, 208, pp. 5–11. Available at: https://doi.org/10.1016/j.procs.2022.10.002 (Accessed: 4 October 2024)	Conference Paper	2022	4	NA	Snowballing	Y	3
Han, Y. (2023) 'Using mobile applications in the study of vocal skills', Education and Information Technologies, 28(2), pp. 2107–2127. Available at: https://doi.org/10.1007/s10639-022-11268-1.	Journal Article	2023	0	technology in vocal education	Google Scholar	Y	6
Harry, A. and Sayundin, S. (2023) 'Role of AI in Education', Injurity: Interdisciplinary Journal and Humanity, 2(3), pp. 260–268. Available at: https://doi.org/10.58631/injurity.v2i3.52.	Journal Article	2023	0	artificial intelligence in education	Google Scholar	Y	2
Henny, J. (2024) 'Episode 389, Learning to Sing with AI" The Intelligent Vocalist with John Henny, The John Henny Vocal Studio [Podcast]. 12 September. Available at https://johnhenny.com/episode-389-learning-to-sing-with-ai/ (Accessed 12 September 2024).	Podcast	2024	NA	NA	NA	N	1
Huang, D. (2024) 'An objective evaluation method of vocal singing effect based on artificial intelligence technology', Applied Mathematics and Nonlinear Sciences, 9(1), pp. 1-13. Available at: https://doi.org/10.2478/amns-2024-0865.	Journal Article	2024	0	artificial intelligence in vocal education	UWTSD Database	Y	1
Huriye, A.Z. (2023) 'The Ethics of Artificial Intelligence: Examining the Ethical Considerations Surrounding the Development and Use of AI', American Journal of Technology, 2(1), pp. 37–45. Available at: https://doi.org/10.58425/ajt.v2i1.142.	Journal Article	2023	0	ethical considerations in ai transparency	Google Scholar	Y	2
IBM (2024) What is AI? Available at: https://www.ibm.com/topics/artificial-intelligence (Accessed: 14 May 2024).	Website	2024	NA	artificial intelligence definition	Google	Grey Literature	1
Isleindia (2024) What is Artificial Intelligence in 2023? Types, Trends. Available at: https://isieindia.com/what-is-artificial-intelligence-in-2023-types-trends/. (Accessed: 3 October 2024).	Website	2023	NA	types of artificial intelligence	Google	Grey Literature	1
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Jestley, J.A. (2011) Metaphorical and Non-Metaphorical Imagery Use In Vocal Pedagogy: An Investigation Of Underlying Cognitive Organisational Constructs. PhD thesis. University of British Columbia. Available at: https://www.academia.edu/64115753/Metaphorical_and_non_metaphorical_imagery_use_in_vocal_pedagogy_an_investigation_of_underlying_cognitive_organisational_constructs. (Accessed: 3 October 2024).	PhD Thesis	2011	0	imagery in vocal education	Google	Grey Literature	1
Kar, T. (2021) 'The use of analogy, imagination and metaphors as an instructional tool in voice training: A case study', Journal for the Interdisciplinary Art and Education, 2(1), pp. 9–31. Available at: https://doi.org/10.29228/jiae.12.	Journal Article	2021	0	imagery in vocal education	Google	Y	1
Keita, Z. (2023) AI and Music Education. Available at: https://nafme.org/blog/ai-in-education/ (Accessed: 7 May 2024).	Website	2023	NA	artificial intelligence in music education	Google	Grey Literature	1
Khan, H. (2021) 'Types of AI | Different Types of Artificial Intelligence Systems' fossguru.com/types-of-ai-different-types-of-artificial-intelligence-systems. Available at: https://www.researchgate.net/publication/355021812_Types_of_AI_Different_Types_of_Artificial_Intelligence_Systems_fossgurucomtypes-of-ai-different-types-of-artificial-intelligence-systems. (Accessed: 3 October 2024).	Website	2021	NA	types of artificial intelligence	Google	Grey Literature	3
Konidena, B.K., Malaiyappan, J.N.A., and Tadimarri, A. (2024) 'Ethical Considerations in the Development and Deployment of AI Systems', European Journal of Technology, 8(2), pp. 41–53. Available at: https://doi.org/10.47672/ejt.1890	Journal Article	2024	0	artificial intelligence ethics	Google Scholar	Y	1
Krishnan, C., Babbar, M., & Singh, G. (2023). *Digital Transformation in Education: Emerging Markets and Opportunities* . Bentham Science Publishers.	Book	2023	NA	NA	Snowballing	Book	1
Kuipers, B., Feigenbaum, E.A., Hart, P.E., and Nilsson, N.J. (2017) 'Shakey: From Conception to History' AI Magazine, 38(1), pp. 88–103. Available at: https://doi.org/10.1609/aimag.v38i1.2716	Journal Article	2017	25	first remote controlled AI-->Shakey the robot	Google Scholar	Y	1
Lã, F.M.B. and Fiuza, M.B. (2022) 'Real-Time Visual Feedback in Singing Pedagogy: Current Trends and Future Directions', Applied Sciences, 12(21), Available at: https://doi.org/10.3390/app122110781.	Journal Article	2022	4	NA	Snowballing	Y	1
Lawrence Livermore National Laboratory (2024) The birth of Artificial Intelligence (AI) research. Available at: https://st.llnl.gov/news/look-back/birth-artificial-intelligence-ai-research (Accessed: 28 June 2024).	Website	2024	NA	types of artificial intelligence	Google	Grey Literature	1

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Marks, R. (2013) 'I Learned It From YouTube! (And Other Challenges of Teaching Voice', Journal of Singing, 69(5), pp. 589-592. Available at: https://www.proquest.com/docview/1355490801?parentSessionId=glMeFqQpO8Fe3it2mRLzajAStu52jW19dDGKmgLmlHU%3D&accountid=130472&sourcetype=Scholarly%20Journals.	Journal Article	2013	3	online voice lessons	Google	Y	2
Nur Fitria, T. (2023) 'The Use of Artificial Intelligence In Education (Aied): Can Ai Replace The Teacher's Role?', EPIGRAM, 20(2), pp. 165–187. Available at: https://doi.org/10.32722/epi.v20i2.5711.	Journal Article	2023	0	Hesitancy to use AI in education	Google Scholar	Y	4
Ovcharenko, N., Samoilenko, O., Moskva, O., and Chebotarenko, O. (2020) 'Innovative Technologies in Vocal Training: Technological Culture Formation of Future Musical Art Teachers', Journal of History Culture and Art Research, 9(3), pp. 115-126. Available at: http://dx.doi.org/10.7596/taksad.v9i3.2729.	Journal Article	2020	6	artificial intelligence in vocal education	Google Scholar	Y	5
Prior, J., Ferguson, S. & Leaney, J. (2016) 'Reflection is hard: teaching and learning reflective practice in a software studio', Proceedings of the Australasian Computer Science Week Multiconference. Presented at the ACSW '16: Australasian Computer Science Week, ACM, Canberra Australia, pp. 1–8. Available at: https://doi.org/10.1145/2843043.2843346.	Conference Paper	2016	15	Reflective model software	Google	Y	1
Revolve.AI (2024) The Future is ANI: A Comprehensive Guide to Artificial Narrow Intelligence. Available at: https://revolveai.com/artificial-narrow-intelligence/. (Accessed: 3 October 2024).	Website	2024	NA	Artificial Intelligence Strong Narror	Google	Grey Literature	1
Sarkar, S. and Bhatia, G. (2021) 'Writing and appraising narrative reviews', Journal of Clinical and Scientific Research, 10(3), pp. 169-172. Available at: https://doi.org/10.4103/jcsr.jcsr_1_21	Journal Article	2021	3	Narrative review in research	Google Scholar	Y	1
Schön, D.A. (1987) *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions.* Jossey-Bass.	Book	1987	8462	Schön	Google Scholar	Book	1
Shi, F. et al. (2020) 'Recent Progress on the Convergence of the Internet of Things and Artificial Intelligence', IEEE Network, 34(5), pp. 8–15. Available at: https://doi.org/10.1109/MNET.011.2000009	Journal Article	2020	23	artificial intelligence in education	Google	Y	1
Strubell, E., Ganesh, A., McCallum, A., 2019. Energy and Policy Considerations for Deep Learning in NLP.	Journal Article	2019	1308	Snowballing	UWTSD Database	Y	1
Sukhera, J. (2022) 'Narrative Reviews: Flexible, Rigorous, and Practical', Journal of Graduate Medical Education, 14(4), pp. 414-417. Available at: https://doi.org/10.4300/JGME-D-22-00480.1.	Journal Article	2022	9	Narrative review in research	Google Scholar	Y	1

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UMASS Lowell Magazine Staff (2024) 'AI Friend or Foe?' UMass Lowell Magazine 27(1), Available at: https://www.uml.edu/magazine/alumni-magazine.aspx (Accessed: 16 June 24).	University Magazine Article	2024	NA	NA--came in the mail	NA	University Publication	1
Uzumcu, O. and Acilmis, H. (2024) 'Do Innovative Teachers use AI-powered Tools More Interactively? A Study in the Context of Diffusion of Innovation Theory', Technology, Knowledge, and Learning, 29, pp. 1109–1128. Available at: https://doi.org/10.1007/s10758-023-09687-1.	Journal Article	2024	0	Hesitancy to use AI in music education	Google Scholar	Y	4
Walter, Y. (2024) 'Embracing the future of Artificial Intelligence in the classroom: the relevance of AI literacy, prompt engineering, and critical thinking in modern education', International Journal of Educational Technology in Higher Education, 21. Available at: https://doi.org/10.1186/s41239-024-00448-3	Journal Article	2024	0	Hesitancy to use AI in vocal education	Google Scholar	Y	3
Wang, A. and Zhang, L. (2022) 'Design and Implementation of Computer Visualization Assisted Vocal Music Teaching System', Computer-Aided Design and Applications, 19, pp. 44–55. Available at: https://doi.org/10.14733/cadaps.2022.S7.44-55.	Journal Article	2022	0	technology in vocal education	Google Scholar	Y	1
Woodruff, K., Hutson, J., and Arnone, K. (2023) 'Perceptions and Barriers to Adopting Artificial Intelligence' in K-12 Education: A Survey of Educators in Fifty States', in Reimagining Education - The Role of E-learning, Creativity, and Technology in the Post-pandemic Era. Faculty Scholarship, pp. 1-28.Available at: https://digitalcommons.lindenwood.edu/faculty-research-papers/506.	Journal Article	2023	0	Hesitancy to use AI in education	Google Scholar	Y	3
Yang, G. and Yang, L. (2020) 'Exploration of Vocal Music Teaching Mode from the Perspective of the Age of Artificial Intelligence', International Journal of Frontiers in Engineering Technology, 2(1), pp. 31-40. Available at: https://francis-press.com/papers/1462.	Journal Article	2020	0	Artificial intelligence vocal education	UWTSD Database	Y	6
Yuan, Y., (2024) 'Influencing Factors and Modeling Methods of Vocal Music Teaching Quality Supported by Artificial Intelligence Technology', International Journal of Web-Based Learning and Teaching Technologies, 19(1), pp. 1–16. Available at: https://doi.org/10.4018/IJWLTT.340030.	Journal Article	2024	0	artificial intelligence in music education	Google Scholar	Y	1
Zamfirescu-Pereira, J.D., Wong, R.Y., Hartmann, B., and Yang, Q. (2023) 'Why Johnny Can't Prompt: How Non-AI Experts Try (and Fail) to Design LLM Prompts', Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems Presented at the CHI '23: CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, Article 437, pp. 1–21. Available at: https://doi.org/10.1145/3544548.3581388.	Conference Paper	2023	14	AI prompt issues	Google	Y	2