ECE 1778 Final Report

Re-Sonate

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Word Count: 2420

1. Introduction

It is common to hear people say they have a bad voice or that they "wouldn't be caught dead singing." Not being able to sing, or having the perception of not being able to sing means that one is unable to access the well-researched positive benefits of singing including increased well-being, social cohesion, and avenues for self-expression. For those who wish to improve their voice the cost of vocal training is prohibitive. Online study videos do not offer the feedback from a coach. Mobile phone apps tend to focus on singing the correct note, rather than improving vocal quality. There is a need for quality educational resources that support beginning singers in improving vocal skills and being able to self-asses during their learning journey. The more students are able hear *and* see the impact of their practice, the more they can gain confidence.

The Re-Sonate app aims to meet these needs. The goal of the 'Re-Sonate' app is to help student singers improve their ability to:

1. Sustain their voice over time (necessary for sustaining long and smooth phrases).
2. Produce a rich, resonant vocal tone (necessary for projection and effective communication).

Re-Sonate enables singers to practice and test their skills, as well as to take lessons to learn and improve their skills. Re-Sonate provides feedback through dynamic visual representation and quantifiable analyses to help singers see and hear their progress.

2. Statement of Functionality & Screen Shots from App

- Breath Control Practice

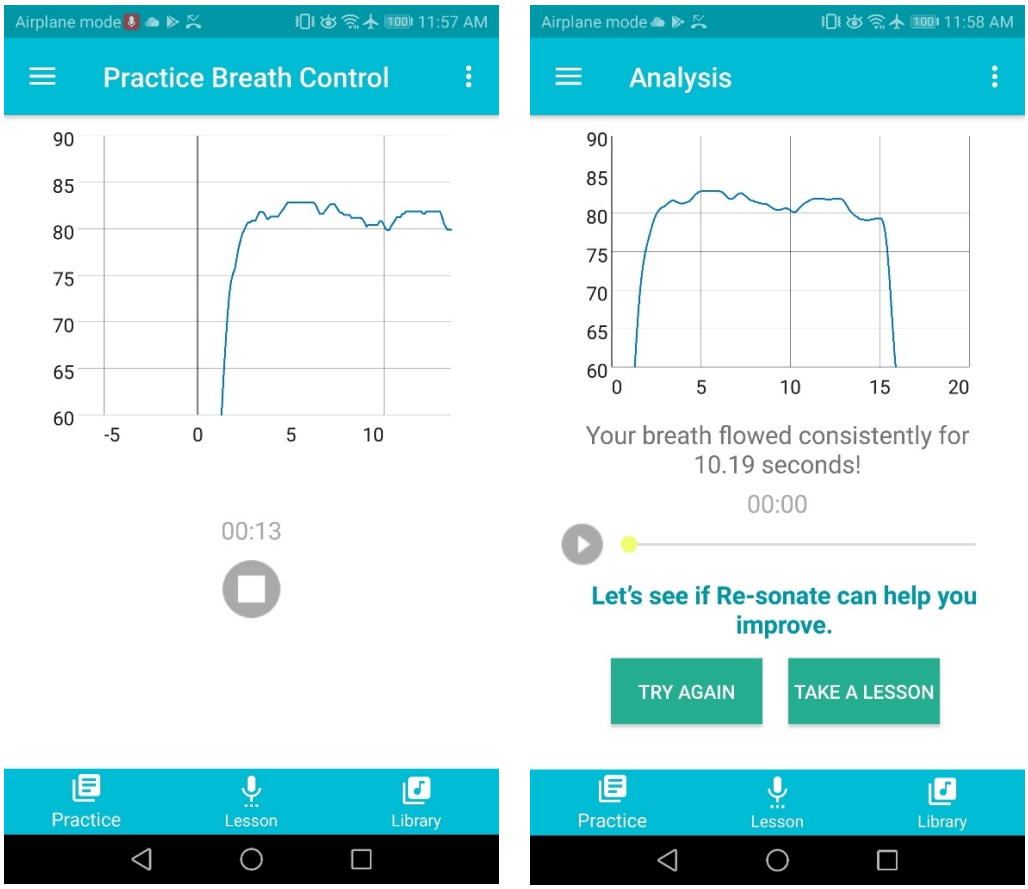


Figure 1. Screenshots of the Breath Control Practice and its Corresponding Analysis

Our first function is called Breath Control Practice (Figure 1). Users are asked to sing any note and vowel for as long as they can. Re-Sonate displays a live feedback graph measuring sound intensity from the voice after users press the record button. Then, our algorithm detects how long users sustain their sound intensity at a certain level. Re-Sonate displays feedback on an analysis page after the stop recording button is pressed. On the analysis page, users may playback the recording, go back to the practice page to try again, or go to a lesson page that helps them improve their breath control skill.

- Breath Control Lesson

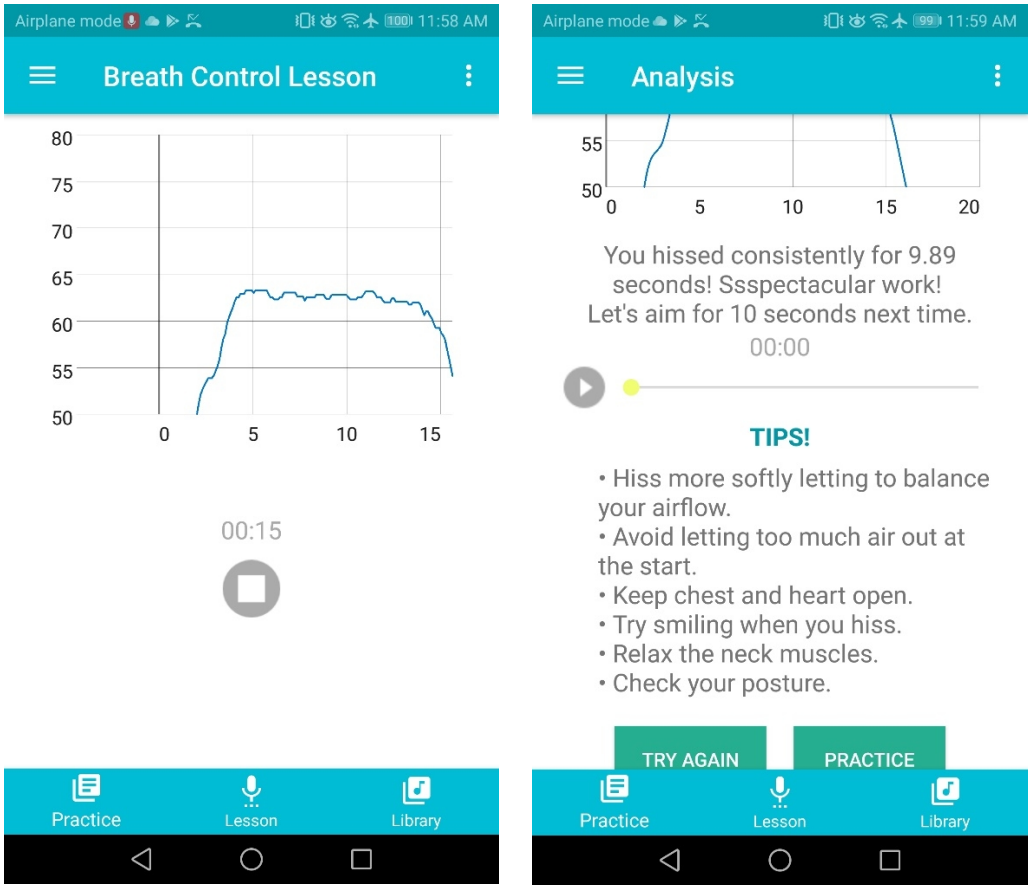


Figure 2. Screenshots of the Breath Control Lesson and its Corresponding Analysis

Our next function, namely Breath Control Lesson (Figure 2), has an algorithm very similar to the one in Breath Control Practice, except some parameters are calibrated so that the sensor is more sensitive to volume changes as the sound intensity on this lesson is expected to be relatively low. In this section, users are asked to generate a hissing sound as long as they can, after which a corresponding lesson is provided. Again, our algorithm provides a live feedback graph of intensity while recording and presenting an analysis page after the recording is ended. On the analysis page, other than the playback function and the options to try again or go back to the practice page several related tips are also provided.

- Vocal Resonance Practice

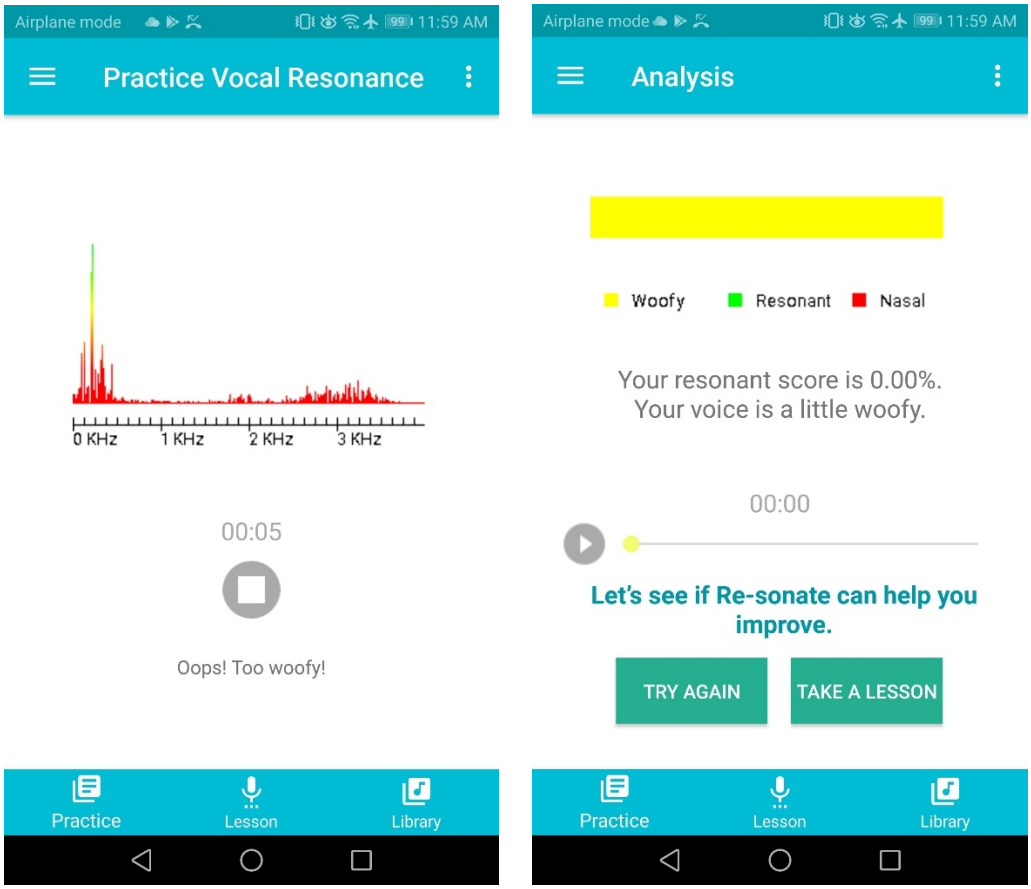


Figure 3. Screenshots of the Vocal Resonance Practice and its Corresponding Analysis

Our third function is called Vocal Resonance Practice (Figure 3). Users are asked to sing any note using the 'ee' vowel for 10 to 15 seconds. Re-Sonate displays a live feedback spectrum analysis graph measuring the voice input after users press the record button. Our algorithm analyzes the voice in three categories: 1) Woofy, dark sound; 2) Resonant, bright sound; and 3) Nasal, edgy sound. Re-Sonate calculates the percentage of resonance in the voice. Re-Sonate provides instructions for helping the user understand the graphs in all three categories before recording. After the stop button is pressed, Re-Sonate displays an analysis page. Users may playback the recording, go back to the practice page to try again, or go to a lesson page that helps them improve their vocal resonance skill.

- Vocal Resonance Lesson

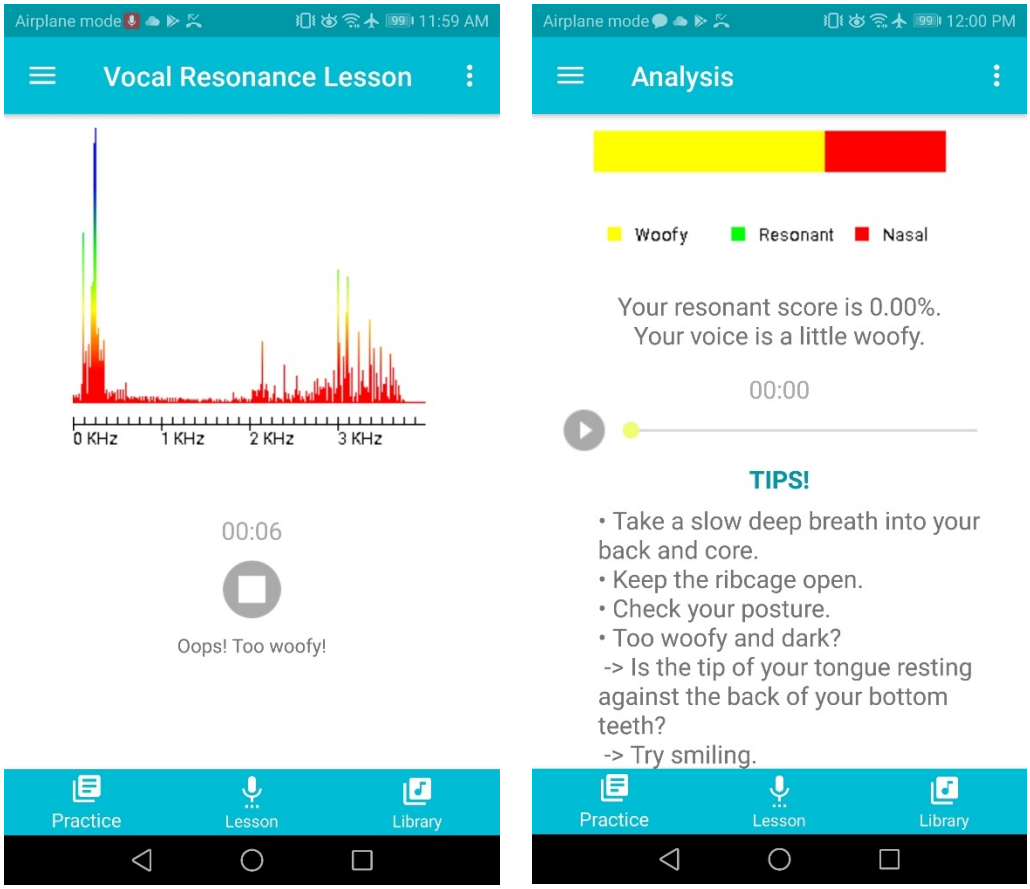
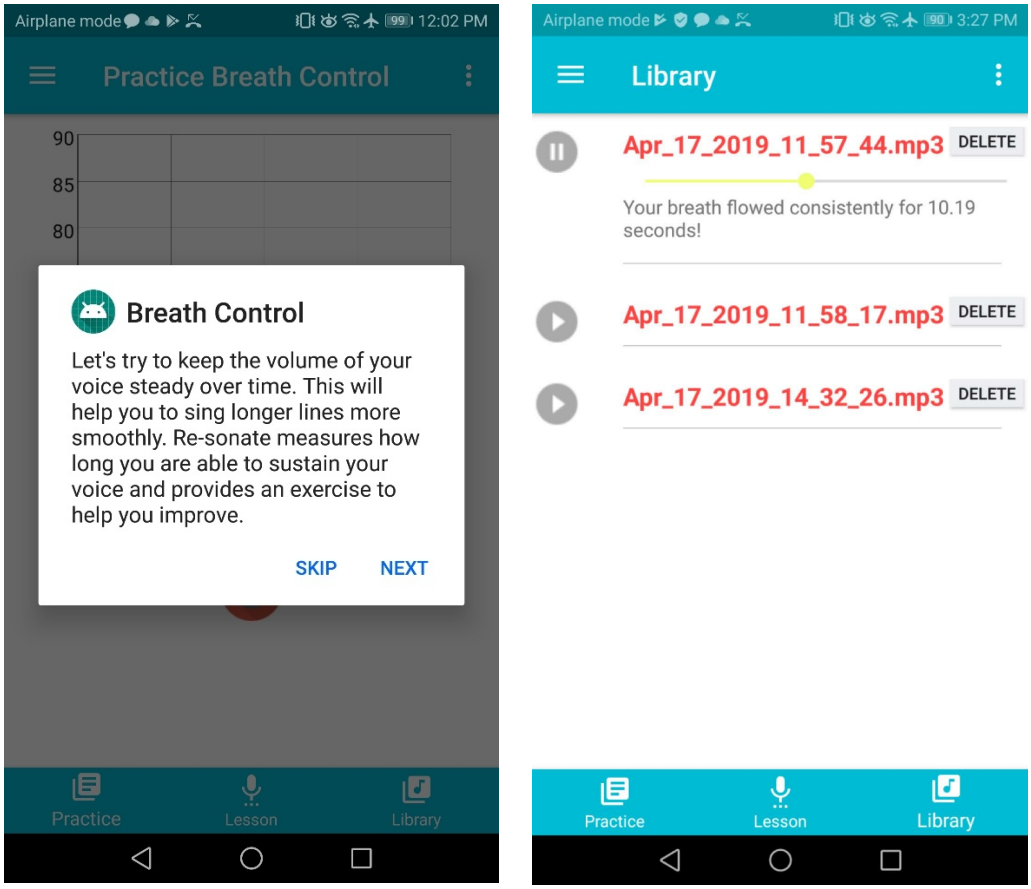


Figure 4. Screenshots of the Vocal Resonance Lesson and its Corresponding Analysis

Our next function, namely Vocal Resonance Lesson (Figure 4), has the same calculation algorithm as the one in Vocal Resonance Practice. In this section, a lesson about how to generate a more resonant voice is presented. On the analysis page, corresponding tips are again provided in addition to the functions described in the Vocal Resonance Practice Analysis section.

- Extra functions and incomplete functions



(a) (b)

Figure 5. Screenshots of (a) the User Instructions and (b) the Library

For each function described above, user instructions are provided before users get into the function. Figure 5(a) shows the instruction users get after choosing Breath Control Practice. Users may either skip the series of instructions or go through them page by page. Re-Sonate also provides a Library function that stores both the recordings and the analyses for the Breath Intensity Lesson, as shown in Figure 5(b). Users may playback the recordings or delete them on this page. We haven't figured out how to store the recordings for the Vocal Resonance Lesson yet, due to the fact that the spectrum analyses are generated using a function that accesses lower levels of the mobile hardware. Therefore it is trickier to access to the recording files.

3. Overall Design

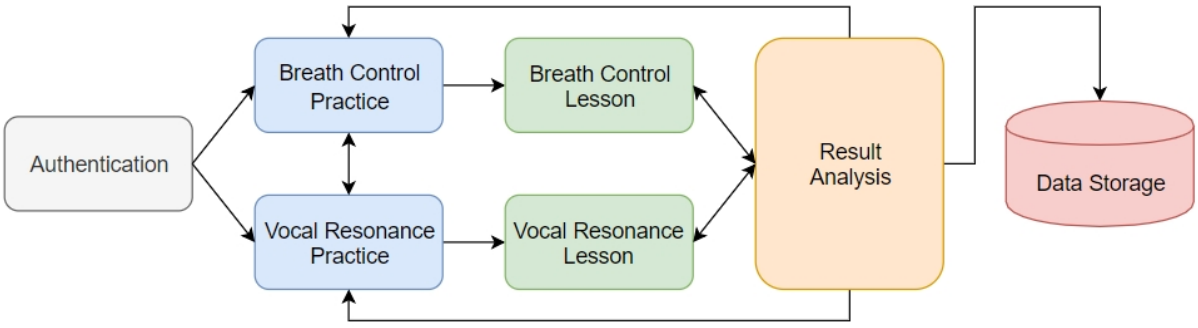


Figure 6. Block Diagram of the Re-Sonate App

Figure 6 shows the block diagram of the Re-Sonate app. In order to use the app, users first need to register an account or login to an existed account. After authenticating, users choose one of the Re-Sonate practice features, namely Breath Control and Vocal Resonance, to get a baseline of their level of singing. Users can switch between these two aspects at any time. After the baseline is provided, users may take corresponding lessons in order to improve their singing skills. Result analyses and related tips are provided after each time users finish their recording in the lesson section. Both the recordings and the analyses are stored in the database. After an analysis is provided, users may either repeat the lesson or go back to the practice to apply their learnings from the lesson. For each part of the app, helper information is provided in advance so that users can learn how to use the functions provided by the app.

4. Reflection

One of our key learnings is that it takes time for people from different academic backgrounds to understand each other's perspectives and ways of approaching a problem or project. While we had some moments of push and pull, we found that over time we began to build a solid rapport where we could honestly share our points of view and come to a place of ease and understanding. In the future we would spend more time discussing our unique backgrounds and giving each other a deeper experience of those backgrounds before making decisions about the project.

A second key learning is that while it was easy to brainstorm ideas and get excited about future possibilities, it was important to settle on one idea early on. Without settling on one idea early on the project has the risk of scope creep and staring off on unstable ground. In the future we would weave into our process a way of choosing one idea, developing the technology for that one idea, and then brainstorm ways to enrich and expand the idea.

A third key learning is that within the given project time constraints it was necessary to be more realistic about what could be achieved. Our team was overly optimistic about the amount of time it would take to design, collaborate, translate expertise into coding language, develop code and track issues. In the future, we would create a project plan and schedule, with agreements on when and how to limit ideas.

5. Contribution by Each Group Member

Hussein Janmohamed — Hussein provided feedback on app features and functionality. He provided his expertise on vocal techniques and how they impact the voice. He did not enter the project with necessary expertise related to the scientific visual properties of vocal resonance or analysis of spectral graphs, so he undertook research and met with colleagues to better understand its function. Hussein provided a user interface Marvel design and he attended weekly meetings as well as participated on video or WhatsApp group chats as necessary. Hussein also generated the app text to guide users through the features and lessons.

Tianyi Xie — Tianyi was responsible for team communication and project management. He set up goals and schedules for each spiral and assigned tasks to each programmer (including himself). He translated Hussein's specialized knowledge to design algorithms that enable the app to quantify aspects of breath control and vocal resonance. Tianyi also implemented an algorithm that could generate a real-time line graph that shows the voice intensity from the microphone input.

Wenhuan Gao — Wenhuan developed most of the user interfaces including the layout of the app, the login function, and the user instructions function. She implemented an algorithm that could generate a real-time spectral analysis graph from the microphone voice input. She also took charge of constructing and maintaining the database, which stores information of the analyses generated by the Re-Sonate app for each user.

6. Specialist Context

Setting the Context

I come to this project with expertise as a choral conductor and vocalist. All too often I meet people who tell me they have a bad voice or that they would never sing in public. These negative perceptions about the voice often means that these individuals end up not singing or participating socially in activities like karaoke with friends or congregational/social singing. This reality for many disheartens me because along with experiencing first-hand the positive impacts of singing there is ample research in the field that demonstrates the positive benefits

of singing including increased mental, physical, spiritual and emotional well-being, increased social cohesion, reduction of anxiety and providing avenues for self-expression.

Barriers

For those who want to learn, lessons are too expensive. Those who do study voice require ongoing feedback in between lessons as it takes time develop the skills to hear the incremental improvement in one's own voice. Do-it-yourself online voice tutorials do not provide singers qualitative or quantitative feedback. Existing mobile apps tend to focus on analyzing how well the user matches notes rather than on providing a holistic view of singing, or improving the voice.

What we achieved

What we have achieved through this project is creating an app that helps fills these gaps. The Re-Sonate app provides live feedback to singers to improve their breath control and achieve rich vocal resonance. Singers are able to hear *and* see their progress, and use the quantifiable analyses as feedback to develop their skills. Through lessons and tips singers are able to deepen their learning experience. While we acknowledge that developing one's voice is a holistic process, we are excited about discovering how an app like Re-Sonate can contribute to improving one's voice by focusing on specific technical aspects like breath control and vocal resonance.

Anticipated Influence on the research field

It is anticipated that the Re-Sonate app will function as a vocal companion alongside online-coaching, one-one-one vocal lessons or group singing classes enabling singers to develop their techniques and practice their skills between lessons with some autonomy. The Re-sonate app can provide voice teachers with a much-needed supportive tool to demonstrate skills and teach students how and what to practice. The unique feature of providing live dynamic visual feedback (through spectral and line graphs) enables students to tap into not only kinesthetic and audio learning but also visual learning modalities. Because it takes time to develop the ear to hear incremental changes in vocal development, having the visual component allows singers to also *see* the impact of their practice. Having a feature displaying simplified spectral graph representations brings into the field a scientific dimension that is otherwise not used in teaching and more often only accessible through experts in vocal health or language centres. The spectral graph feature could open up new possibilities for pedagogy and deepening student learning without requiring one to read cumbersome scientific studies and research in the physics of sound.

7. Future Work

Augmenting the Project

1. We could build into the design a way for truly taking the singer through a holistic journey of learning how to sing. Currently, the project specializes on individual vocal techniques, but our team could consider a more integrated approach that emulates the experience of taking lessons in person.
2. Leading the engineers through actual vocal lessons and having them observe singing lessons taught by different teachers would help the programmers better understand the 'journey' of the singer learning.
3. The project would benefit greatly from our team visiting a voice clinic or linguistic centre where spectral graphs and other technologies are used.
4. The project could be better informed through partnerships and collaborations with a team of vocalists and students at various stages of their vocal development who would provide further expertise, feedback and testing.
5. Adding research components such as interviews, focus groups and one-on-one testing with voice teachers, vocal acoustic specialists and engineers would help with project validity, consistency, reliability and inform practical application.

Suggestions of additional features and capabilities

1. Calibrate the Re-Sonate vocal resonance and spectral analysis feature for other vowels (ie. e, a, o, u) beyond the current app's calibration on the 'i' (ee) vowel. This would permit the user to test out the consistency of their resonance across the spectrum of vowels they sing.
2. Gamify Re-Sonate to provide users with challenges and a reward system to motivate their learning and celebrate their achievements.
3. Integrate into each Re-Sonate feature (eg. Breath Control) a variety of lessons that provide a multi-focal approach to developing that particular skill.
4. Scaffold Re-Sonate's lesson plans, vocal lessons and technical exercises so that users can start with foundations like singing on one tone and gradually build to singing longer phrases and songs.
5. Improve on the Re-Sonate user interface design with animations and graphics.
6. Enable users to track their progress over time through charts and graphs.
7. Enable users to share their progress and recordings with teachers and friends as desired.

8. Publication

All group members agree that the final presentation video and PowerPoint presentation, as well as this report may be publicly posted. We would like to keep our source code unpublicized, as we may continue to further develop and implement additional features/capabilities. We also hope to commercialize Re-Sonate at some point in the future.