Original Research Article

AI Violin Tutor Applications for High School Students in the San Francisco Bay Area: A Student-Centered Mixed-Methods Evaluation

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ABSTRACT

This study aimed to identify which features of three AI violin tutor applications—Trala, Violy, and Caidence—high school violinists perceived as most supportive when learning a new piece of music. Traditional violin pedagogy often depends on individualized instruction, which can limit access for students who face financial and logistical barriers to private lessons and high-quality coaching. Prior studies on AI-assisted violin learning have largely emphasized listener-based evaluations or technical system performance rather than students' direct experiences of using the tools. The present study addressed that gap through a student-centered, mixed-methods, quasi-experimental design with 12 high school violinists from one competitive high school in the San Francisco Bay Area. Each participant completed a single 45–60 minute session in which all three applications were used sequentially, followed by a structured reflection survey. Data sources included Likert-scale survey responses, open-ended survey responses, and observational field notes. Qualitative analysis used deductive coding focused on visual design and interface, feedback clarity and accuracy, and perceived effectiveness. Quantitative analysis was descriptive and exploratory. Trala was the most preferred application, selected by 8 of 12 participants, and was described as strongest for immediate intonation feedback. Violy was perceived as more useful for complete run-throughs of longer excerpts but less clear in locating errors. Caidence was least effective for technical correction but was valued by some participants for stylistic and interpretive guidance. Across applications, the most salient characteristics were immediate feedback, clarity of explanation, and interface simplicity. These findings suggest that the educational value of AI violin tutors depends not only on technical capability but also on how clearly feedback is communicated to learners. Because the study used a small, geographically homogeneous sample and a single-session design, the findings should be interpreted as preliminary and descriptive.

Keywords: violin pedagogy; artificial intelligence; student-centered evaluation; music education; high school students; digital learning accessibility

INTRODUCTION

Access to sustained, high-quality violin instruction is often shaped by resources that are unevenly distributed, including family income, availability of private teachers, transportation, and school-based arts opportunities. Research on music education access has described how financial constraints and broader structural inequalities can limit youth participation in classical music learning environments, particularly when advancement depends on private lessons, ensemble placement, and

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individualized coaching (1, 2). In performance-based instruction such as violin pedagogy, these barriers matter because technical and interpretive growth often depend on frequent expert feedback.

Traditional violin pedagogy has historically relied on individualized teacher-student relationships and on instructional lineages derived from influential pedagogical traditions. Early and modern scholarship on violin teaching has traced the field's development from foundational treatises, including Leopold Mozart's 1756 treatise, through later national and stylistic "schools" of playing (3, 4). Although these traditions have shaped modern violin instruction in productive ways, they also reinforce a model in which progress is closely tied to regular teacher access, time-intensive feedback, and opportunities that are not equally available to all students.

Artificial intelligence (AI) has increasingly been proposed as a supplemental tool that could expand access to music learning. Across music and the arts, AI systems have been used for composition, sound generation, classification, and performance analysis (5-7). In violin pedagogy more specifically, earlier research has explored augmented-reality and computer-vision systems for bow and finger placement, while more recent studies have investigated machine-learning systems that can analyze pitch and rhythm and respond to student playing in real time (8-11). Other work has examined AI-driven automated evaluation systems designed to support music learning by offering standardized feedback on performance parameters such as intonation, rhythm, and timbre (12).

Despite these developments, a recurring limitation in the literature is that many evaluations emphasize either technical system performance or judgments made by outside listeners rather than the perspectives of students using the applications themselves. Student-centered evidence is especially important in educational technology research because the usefulness of a system depends not only on whether it detects an error but also on whether learners understand the feedback, can act on it, and perceive the tool as supportive during practice. In addition, research involving orchestral music education suggests that participation and learning benefits are linked to educational context, mindset, and access conditions, further underscoring the value of examining how students actually experience music-learning technologies (13).

The present study therefore examined three publicly available AI violin tutor applications—Trala, Violy, and Caidence—from the perspective of high school violin students in the San Francisco Bay Area. Trala and Violy were selected because they incorporate real-time or

near-real-time performance analysis, while Caidence represents a generative AI-based approach centered on text-based musical guidance. The study asked the following research question: What characteristics of AI violin tutor applications do high school violin students perceive as most effective when learning a new piece of music? Based on prior literature on AI feedback systems in music education, the working hypothesis was that students would perceive applications with immediate, specific, and actionable feedback on intonation and rhythm as more effective than applications that provide delayed, vague, or generalized feedback (10-12). This hypothesis reflects what was directly tested in the present study: student perceptions of feedback quality, usability, and overall effectiveness.

LITERATURE REVIEW

Violin pedagogy and access

Violin pedagogy has a long history, with instructional methods emerging in the sixteenth century and becoming formalized through major pedagogical texts and performance traditions (3, 4). These systems have proven effective for training skilled musicians, but their dependence on individualized instruction limits scalability. Literature on access to classical music education has also noted that youth participation is shaped by cost, geography, and institutional opportunity, with lower-income students facing greater barriers to sustained participation and advancement (1, 2).

AI in music and violin instruction

AI applications in music span generative systems, performance tools, and analytical models. Deep learning has enabled systems to perform increasingly complex tasks in artistic contexts, while generative AI has become common in music creation and experimentation (5-7). In violin-specific research, studies have described augmented-reality instruction, audio-based analysis, and AI-assisted tutoring systems that respond to performance in real time (8-11). Machine-learning approaches appear especially promising for technical correction because they can process performance input dynamically and return immediate responses (10, 11).

Need for student-centered evaluation

Although AI systems are often presented as ways to

democratize access to instruction, evaluation of these tools has not consistently centered learners' perspectives. Existing work on violin AI applications has commonly emphasized listener judgments or system capabilities rather than how students interpret and use the feedback in practice (10-12). The present study addresses that gap by focusing on students' direct evaluations of three applications during structured practice sessions.

METHODS AND MATERIALS

Research Design

This study used a small-scale, student-centered, mixed-methods quasi-experimental design. All participants evaluated the same three applications—Trala, Violy, and Caidence—during a single individual session. Trala and Violy were classified in the manuscript as deep-learning-based applications because they provide performance-responsive feedback, whereas Caidence was classified as a generative AI application because it provides text-based guidance rather than direct real-time audio analysis. The aim was not to measure long-term skill growth but to identify which application features students perceived as most supportive during short practice interactions.

Participants and Sampling

Participants were recruited from the orchestra program at one competitive high school in the San Francisco Bay Area using voluntary response sampling. Recruitment flyers were distributed by orchestra directors to eligible students. Inclusion criteria were enrollment in the school music program, violin study for at least two years, and willingness to participate with parental permission and student assent. Twelve students participated.

Participants self-classified their skill level on the assent form using two study-defined categories. Seven participants identified as Proficient, meaning able to perform moderately difficult high school repertoire with solid shifting and bowing technique. Five participants identified as Advanced, meaning able to perform more difficult repertoire confidently with more complex shifting and bowing demands. Skill level was collected for descriptive purposes only and was not used analytically because the sample was too small for meaningful subgroup testing.

Procedure

Each participant completed one individual session lasting approximately 45–60 minutes. During the session, participants interacted with all three applications in the same overall order used in the original study procedures. Each application was used for approximately 15–20 minutes. For Trala, participants practiced Air on the G String by J. S. Bach. For Violy, they practiced Student Violin Concerto in B Minor, 1st Movement by Oskar Rieding. For Caidence, they practiced Violin Concerto No. 2 by Friedrich Seitz. These pieces were selected to align broadly with high-school-level violin repertoire.

During each segment, the researcher observed silently and recorded field notes about participants' interactions, visible frustrations, feature use, and navigation behavior. No coaching or clarification was provided during the app trials so that students' reactions would reflect their independent experiences with the applications. After using all three applications, participants completed a structured reflection survey.

All three applications were tested under equivalent conditions for every participant. Sessions were conducted in the same quiet practice room using the same device, headphones, internet connection, and audio settings for all trials. The same subscription level and application versions were used for Trala, Violy, and Caidence, and participants received identical standardized instructions before beginning each app segment.

Survey Instrument

The survey contained 10 items. Six items used 5-point Likert-style ratings and four items were open-ended. The quantitative items asked participants to rate, for each application, 1) graphics and user-friendliness, 2) quality and accuracy of rhythmic feedback, and 3) quality and accuracy of intonation feedback. Additional structured items asked participants to identify their favorite application and report prior familiarity with the tested apps. Open-ended questions asked what participants liked most, what frustrated them, what kind of feedback felt most useful, and why they chose a preferred application. The survey also asked participants whether they had previously used Trala, Violy, or Caidence; all twelve participants reported no prior experience with any of the three applications, so usability and feedback ratings were based on first-time use.

The survey was constructed by the author for this project using themes drawn from the literature review on interface design, feedback clarity, and perceived effectiveness (10-12). The wording was reviewed for clarity with the AP Research instructor before data collection, but the instrument was not formally validated and no pilot study with external participants was

conducted. The survey instrument can be found as a supplementary file (S1).

Data Analysis

Qualitative data from open-ended survey responses and field notes were analyzed using deductive coding. Three a priori codes were used: 1) visual design and interface, 2) feedback clarity and accuracy, and 3) perceived effectiveness. These codes were derived from recurring themes in prior literature on music-learning applications and AI feedback systems (10-12). Participant quotations are presented using pseudonyms.

Quantitative data were analyzed descriptively. Means and simple distributions were calculated for the three main rating categories across applications. Because the sample size was small, the survey instrument was not validated, and the project was designed primarily as an exploratory AP Research study, no inferential statistics were conducted in this revision. All quantitative findings should therefore be interpreted as descriptive and exploratory rather than as evidence of statistically significant differences.

Ethical Considerations

The study involved human participants who were minors at the time of data collection. Written parental consent and student assent were obtained before participation. Participants were informed about the study purpose, time commitment, and procedures. To reduce selection bias, orchestra directors distributed the recruitment materials rather than the student researcher directly approaching eligible students.

During data collection, participants were informed of the name of each application, the assigned piece, and the approximate time available for using the application. Participants were also informed that Trala required a paid subscription of approximately 20 USD per month so that opinions about accessibility and value would be formed with that information in mind.

Participant privacy was protected through de-identification procedures. Pseudonyms were used in the manuscript, no audio or video recordings were collected, and study files were stored in a restricted-access encrypted folder. Raw data were scheduled for deletion at the end of the 2025–2026 academic year.

At the time of the original project, the study was conducted as an AP Research educational project under school supervision. As such the Institutional Review Board of the researcher's high school (Carlmont High School) accepted a proposal detailing the goals for this project and gave it IRB approval (approval number not assigned in school-based review).

RESULTS

Twelve students completed all study procedures. All names reported below are pseudonyms.

Qualitative findings

Visual design and interface: Participants generally described Trala and Violy as easier to navigate than Caidence. Eight participants described Trala as intuitive and easy to use. Several commented positively on its visual display of note errors. One participant, assigned the pseudonym Ben, reported that the hand graphic indicating where a wrong note occurred was engaging and helpful. At the same time, seven participants described Trala's moving tracker bar as distracting during performance.

Violy also received largely positive comments about interface familiarity. Nine participants indicated that the application was easy to navigate, and several said its display looked similar to conventional sheet music. By contrast, Caidence received fewer positive remarks about interface design. Six participants did not comment on its visuals at all, while several others described it as sparse and resembling a generic text-based chatbot interface.

Feedback clarity and accuracy: Feedback quality emerged as the most prominent theme across the three applications. Trala was described as strongest for intonation correction. Ten participants reported that the application reliably identified wrong notes in real time. However, four participants also stated that after detecting a problem, the app did not always explain how to correct it, such as whether the note was sharp or flat. Rhythmic feedback in Trala was viewed as less clear. Several participants noted that the app stopped them when rhythm was incorrect but did not explain the specific problem.

Violy's feedback was primarily experienced through its audition mode. Nine participants reported that its rhythmic and intonation feedback was not sufficiently clear because the application marked problems without clearly locating them. Field notes also documented that for four participants, the app's count of errors did not match the student's perception of what happened while playing.

Caidence received the weakest evaluations for technical feedback. Ten participants described its responses as vague for rhythm and intonation. However,

field notes suggested that participants who asked more detailed questions sometimes obtained more useful responses, especially about stylistic interpretation.

Perceived effectiveness: Participants' overall judgments reflected these feedback patterns. Trala was perceived as the most useful for technical practice, especially intonation. Violy was viewed as helpful for complete run-throughs of longer excerpts because it required full performance before generating a summary. Caidence was not seen as effective for direct technical correction, but six participants appreciated its stylistic suggestions and explanatory comments.

Quantitative findings

Quantitative results are reported descriptively. No inferential statistics were used; therefore, the ratings below should be interpreted as exploratory summaries of this sample rather than as confirmed differences. Table 1 presents the mean, median, range, and standard deviation of participant ratings (1–5) for user friendliness/graphics, rhythmic feedback quality, and intonation feedback quality across the three applications.

For user friendliness and graphics, Violy had the highest mean rating (M = 3.67, SD = 1.07), followed closely by Trala (M = 3.58, SD = 1.31), while Caidence had the lowest mean rating (M = 2.92, SD = 1.31). For quality and accuracy of rhythmic feedback, Violy again showed the highest descriptive mean (M = 3.08, SD = 1.31), Trala's mean was lower (M = 2.75, SD = 1.36), and Caidence had the lowest mean rating (M = 2.25, SD = 1.42). For quality and accuracy of intonation feedback, Trala had the highest mean rating (M = 3.42, SD = 1.24), Violy had a lower mean (M = 2.67, SD = 1.37), and Caidence again had the lowest mean rating (M = 2.25, SD = 1.29). In all three rating categories, the observed ranges spanned the full 1–5 scale and standard deviations were consistently around 1.1–1.4, indicating substantial variation in individual responses.

Participants were also asked to identify their preferred application after using all three tools. As shown in Figure 1, 8 of 12 participants selected Trala, 2 selected Violy, and 2 selected Caidence, indicating that Trala was the most frequently preferred application in this sample despite the mixed descriptive rating patterns across specific feedback dimensions.

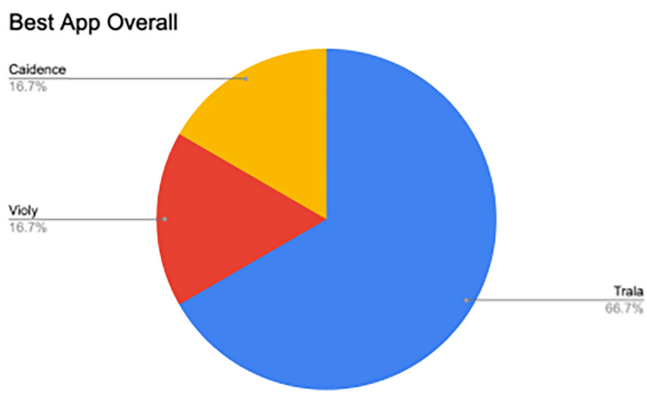

Figure 1. *Pie chart of participants' preferred application (n = 12). The chart shows the proportion of participants selecting Trala, Violy, or Caidence as their favorite application after the session. Trala was the most frequently selected application.*

Table 1. *Descriptive statistics for participant ratings (1–5) of user friendliness/graphics, rhythmic feedback quality, and intonation feedback quality across Trala, Violy, and Caidence (n = 12).*

Rating item	Application	Mean (M)	Median	Range	Standard Deviation (SD)
User Friendliness/ Graphics	Trala	3.58	4	1-5	1.31
	Violy	3.67	4	1-5	1.07
	Caidence	2.92	3	1-5	1.31
Quality/Accuracy of Rhythm Feedback	Trala	2.75	3	1-5	1.36
	Violy	3.08	3	1-5	1.31
	Caidence	2.25	2	1-5	1.42
Quality/Accuracy of Intonation Feedback	Trala	3.42	3	1-5	1.24
	Violy	2.67	3	1-5	1.37
	Caidence	2.25	2	1-5	1.29

DISCUSSION

This study examined how high school violinists perceived three AI violin tutor applications during structured short practice sessions. Across the qualitative and descriptive quantitative findings, immediate feedback, clarity of explanation, and interface simplicity emerged as the characteristics most closely associated with perceived usefulness.

The most consistent finding was that students valued feedback that responded quickly to their playing. Trala was favored by most participants and was described as particularly useful for intonation correction because it flagged incorrect notes in real time. This pattern is consistent with prior work suggesting that machine-learning-based systems can function as interactive tutors by responding dynamically to student input (10-12). At the same time, the present findings suggest that detection alone is not sufficient. Several participants reported that even when an app identified an error correctly, they still needed clearer guidance on how to fix it. This distinction between identifying mistakes and providing usable instruction is educationally important because technical feedback only supports learning if it is interpretable and actionable.

The results also suggest that interface design contributes to perceived effectiveness. Participants generally preferred interfaces that felt visually familiar and easy to navigate. Trala and Violy were both described as more usable than Caidence, but even positively perceived design features could become distracting when they competed with the task of playing. The repeated criticism of Trala's tracker bar indicates that visual support must be balanced against cognitive load.

The comparison between deep-learning-style applications and the generative AI system also revealed complementary rather than identical strengths. Trala and Violy were more useful for technical skill work because they responded to performance. Caidence, which depended on typed prompts rather than continuous listening, was less useful for rhythm and intonation correction but more useful for style-related explanations for some participants. This suggests that generative AI may be better suited as a supplementary interpretive or reflective tool than as a primary technical tutor in its current form.

These findings should be interpreted cautiously. The study was based on a small voluntary sample drawn from a competitive high school in a single geographic region. The design captured impressions from one short session rather than long-term use, and different musical excerpts were assigned to different applications. Given that participants encountered each application for the first time during the study session, the findings illuminate how novice users interpret AI-based violin tutors on initial contact rather than after extended adoption. Longitudinal studies following students over multiple weeks or months of use would be valuable for determining whether these early impressions persist, converge, or diverge with continued practice. In addition, the survey instrument was researcher-developed and not formally validated, and the quantitative analysis was descriptive rather than inferential. Because of these constraints, the manuscript cannot claim that one application definitively outperformed another beyond this sample. Instead, the findings offer preliminary evidence about how students perceived the usability and educational value of these tools during brief encounters.

Within those boundaries, the study still contributes to the literature by foregrounding user experience rather than relying solely on outside evaluators or technical system descriptions. For developers, the findings suggest that more useful AI practice tools will likely combine rapid technical detection with clearer pedagogical explanations. For educators and students, the results indicate that AI applications may be most valuable as supplementary tools for practice rather than replacements for human instruction.

CONCLUSION

This study investigated which characteristics of three AI violin tutor applications high school violin students perceived as most supportive when learning a new piece of music. In this sample, participants most valued immediate feedback, clear explanations, and intuitive interfaces. Trala was most often preferred, largely because participants viewed its intonation feedback as timely and useful, while Caidence was perceived as more appropriate for stylistic guidance than for technical correction.

The study's main contribution is its student-centered perspective on AI-supported violin practice. Rather than evaluating the applications through external listeners alone, it examined how learners themselves understood and used the feedback. That perspective is important for educational technology research because a system's pedagogical value depends on usability and interpretability as well as technical capability.

The findings are preliminary and bounded by several limitations: the small and geographically homogeneous

sample, the single-session design, the use of different repertoire across apps, the lack of inferential statistics, and the use of a non-validated survey instrument. Future work should examine longer-term use, include more diverse participants and sites, and test whether hybrid systems that combine real-time performance analysis with clearer instructional explanation improve both technical learning and user experience.

SUPPLEMENTARY MATERIALS

Supplementary File S1 contains the full reflection survey instrument used in this study, including all Likert-scale and open-ended items.

DATA AVAILABILITY

De-identified survey and field-note data underlying the analyses are available from the author upon reasonable request, subject to institutional and privacy constraints. Because the dataset involves minor participants, any data sharing will exclude direct identifiers and will be limited to aggregate or de-identified records only.

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CONFLICT OF INTEREST

The author declares no conflicts of interest related to this work.

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SUPPLEMENTARY MATERIALS

Final Survey (AP Research AI Application)

Congrats on completing the process! Fill out this quick survey to reflect on your experience with each app.

* Indicates required question

1. Email*

   _____

2. Full Name*

   _____

3. Group Assignment (this was chosen by you in the assent form)*
   Mark only one oval.
   □ Proficient
   □ Advanced

4. Date*

   _____
   Example: January 7, 2019

Trala App

This section focuses on Trala, the first app you tested.

5. On a scale of 1-5 how user friendly would you say Trala was?*
   Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Easy to use and understand

6. On a scale of 1-5 how would you rate Trala's graphics?*
   Mark only one oval.

	1	2	3	4	5	
Poo	□	□	□	□	□	Well-crafted and attractive

7. On a scale of 1-5 how helpful was Trala with improving your rhythm on the piece?*
   Mark only one oval.

	1	2	3	4	5	
Not	□	□	□	□	□	Very helpful

8. Can you provide some reasoning or an example for your answer to the questions above?

   _____
   _____
   _____
   _____
   _____
   _____

9. On a scale of 1-5 how helpful was Trala with improving your intonation on the piece?*
   Mark only one oval.

	1	2	3	4	5	
Not	□	□	□	□	□	Very helpful

10. Can you provide some reasoning or an example for your answer to the questions above?

    _____
    _____
    _____
    _____
    _____
    _____

11. On a scale of 1-5 how easy was it to understand Trala's feedback on your rhythm?*
Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Very easy to understand

12. Can you provide some reasoning or an example for your answer to the questions above?

13. On a scale of 1-5 how easy was it to understand Trala's feedback on your intonation?*
Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Very easy to understand

14. Can you provide some reasoning or an example for your answer to the questions above?

15. What do you believe was Trala's best aspect and why?*

16. What was its worst aspect and why?*

17. Is there any other characteristic of this app that you thought was notable but was notincluded in the form? If so explain your answer.

Violy App

This section focuses on Violy, the second app you tested.

18. On a scale of 1-5 how user friendly would you say Violy was?*
Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Easy to use and understand

19. On a scale of 1-5 how would you rate Violy's graphics?*
Mark only one oval.

	1	2	3	4	5	
Poo	□	□	□	□	□	Well-crafted and attractive

20. On a scale of 1-5 how helpful was Violy with improving your rhythm on the piece?*
Mark only one oval.

	1	2	3	4	5	
Not	□	□	□	□	□	Very helpful

21. Can you provide some reasoning or an example for your answer to the questions above?

22. On a scale of 1-5 how helpful was Violy with improving your intonation on the piece?*
Mark only one oval.

	1	2	3	4	5	
Not	□	□	□	□	□	Very helpful

23. Can you provide some reasoning or an example for your answer to the questions above?

24. On a scale of 1-5 how easy was it to understand Violy's feedback on your rhythm?*
Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Very easy to understand

25. Can you provide some reasoning or an example for your answer to the questions above?

26. On a scale of 1-5 how easy was it to understand Violy's feedback on your intonation?*
Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Very easy to understand

27. Can you provide some reasoning or an example for your answer to the questions above?

28. What do you believe was Violy's best aspect and why?*

29. What was its worst aspect and why?*

30. Is there any other characteristic of this app that you thought was notable but was notincluded in the form? If so explain your answer.

Caidence Website

This section focuses on Caidence, the last application you tested.

31. On a scale of 1-5 how user friendly would you say Caidence was?*
Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Easy to use and understand

32. On a scale of 1-5 how would you rate Caidence's graphics?*
Mark only one oval.

	1	2	3	4	5	
Poo	□	□	□	□	□	Well-crafted and attractive

33. On a scale of 1-5 how helpful was Caidence with improving your rhythm on the piece?*
Mark only one oval.

	1	2	3	4	5	
Not	□	□	□	□	□	Very helpful

34. Can you provide some reasoning or an example for your answer to the questions above?

35. On a scale of 1-5 how helpful was Caidence with improving your intonation on the piece?*
Mark only one oval.

	1	2	3	4	5	
Not	□	□	□	□	□	Very helpful

36. Can you provide some reasoning or an example for your answer to the questions above?

37. On a scale of 1-5 how easy was it to understand Caidence's feedback on your rhythm?*
Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Very easy to understand

38. Can you provide some reasoning or an example for your answer to the questions above?

39. On a scale of 1-5 how easy was it to understand Caidence's feedback on your intonation?*
Mark only one oval.

	1	2	3	4	5	
Very	□	□	□	□	□	Very easy to understand

40. Can you provide some reasoning or an example for your answer to the questions above?

41. What do you believe was Caidence's best aspect and why?*

42. What was its worst aspect and why?*

43. Is there any other characteristic of this app that you thought was notable but was notincluded in the form? If so explain your answer.

Final Reflection

44. Which app did you personally prefer best?*
Mark only one oval.

- □ Trala
- □ Violy
- □ Caidence

45. Please provide three reasons why*