Field Study on Children's Home Piano Practice: Developing a Comprehensive System for Enhanced Student-Teacher Engagement

Seikoh Fukuda¹
PTNA Research Institute
of Music
seikoh@piano.or.jp

Yuko Fukuda¹
Kyoritsu Women's
University²
yuko@piano.or.jp

Masamichi Hosoda
NTT East Corporation
masamichi.hosoda.at
@east.ntt.co.jp

Ami Motomura, Eri Sasao
To-on Kikaku Company
motomura@to-on.com,
e_sasao@to-on.com

Masaki Matsubara
University of Tsukuba
masaki@slis.
tsukuba.ac.jp

Masahiro Niitsuma
Keio University
mniitsuma@keio.jp

ABSTRACT

Regular weekly lessons and daily home practice are key for skill development. This paper focuses on identifying the challenges within such practice routines and developing a system to address these issues, thereby enhancing teacher support and elevating student performance in piano. Observations from real-world lessons and an analysis of practice videos spanning 177 days from 30 students reveal successful tactics, including the assignment of suitably challenging pieces and motivational rewards like stickers or stamps. Furthermore, the study underscores issues such as tension in parent-led practice and ineffective repetition. Insights from the field study suggest the potential of third-party feedback, practice segmentation, reporting practice records to teachers, and rewarding practice sessions. We developed a system incorporating these solutions and tested it with 80 children over 4 months. Results showed increased teacher engagement with students' home practice, improved student motivation and practice duration, and enhanced sight-reading skills, demonstrating the system's effectiveness in supporting piano education.

1. INTRODUCTION

Weekly lessons and daily home practice are vital for skill growth in young piano students [1-3]. However, teachers often rely solely on lesson performance to address issues in unseen home practice. Fostering resilience is essential in daily piano education. Research suggests praising not just outcomes, but also effort and perseverance [4]. Therefore, piano instructors should evaluate and commend not only performance outcomes but also efforts during home practice and the ability to overcome difficulties.

Identifying home practice challenges enables efficient skill improvement through targeted interventions and support systems. This paper aims to **(1)** identify home practice challenges and **(2)** develop a system to address them. This study aims to address issues and evaluate the system's effectiveness in improving practice outcomes.
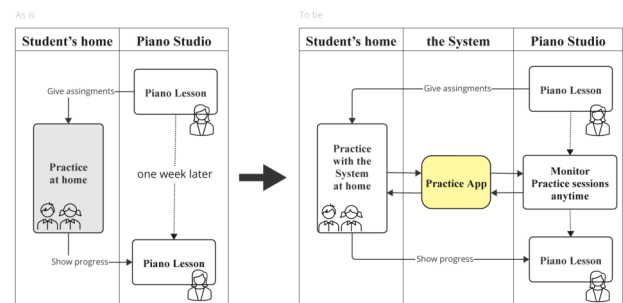

Figure 1. (Left) Current practice (Right) Enhanced System with App.

In 2023, with the cooperation of Piano Teachers' National Association of Japan (PTNA) [5], **(1a)** interviews were conducted with 8 piano teachers, **(1b)** observations were made of the piano lessons of their 12 students, **(1c)** survey results regarding home practice were collected from 81 piano teachers, **(1d)** one-week home practice records were obtained from 37 students (Average age: 7.02), and **(1e)** the analysis of 177 days of home practice videos from 30 of those students (Average age: 6.93) was performed. **(2)** Based on these findings, a support system (Fig. 1) was developed and tested over 4 months with 80 students (Average age: 7.11) and 46 teachers, aiming to enhance practice efficiency and outcomes. These students are a different population from the subjects in survey (1a-1e).

The evaluation of the system's effectiveness, based on its usage and surveys conducted before and after the trial, revealed the following:
- Segmenting tasks of target musical score, which is assigned as homework, increased students' practice time and improved their sight-reading skills.
- Reporting practice time and frequency to teachers increased teachers' awareness of home practice.
- Providing incentives for each piece practiced enhanced students' motivation and initiative to practice.

¹ Seikoh Fukuda and Yuko Fukuda, Co-first author

² Adjunct Instructor at Kyoritsu Women's University

2. FIELD STUDY

2.1 Cultural Background

In Japan, piano lessons are the second most popular extra-curricular activity for elementary school students [6], and almost all students attending piano classes have a piano at home and practice daily. Throughout the 9 years of compulsory education from the first year of elementary school to the third year of middle school, music is consistently a compulsory subject, resulting in high levels of music literacy. Although few children aim to become piano professionals, it is presumed that many parents recognize the educational value of learning music and piano [7]. The educational value of music and piano learning is evident from the fact that many students at major U.S. universities like Harvard and MIT [8] study music as part of their liberal arts education and focus on developing non-cognitive skills [9]. The role of parents in their children's piano learning in Japan is multifaceted. Parents manage the daily practice schedule and maintain their children's motivation through feedback and encouragement. They also work closely with piano teachers, correcting mistakes in place of the teachers to ensure effective practice at home. In this way, active parental involvement significantly impacts the duration and progress of their children's piano learning.

2.2 Lesson Observations and Teacher Interviews

To explore how to maximize the effectiveness of home practice, we invited 8 experienced piano teachers (30s to 60s) to observe 12 lessons across 4 piano classes. These observations, coupled with interviews, highlighted 3 key factors essential for enhancing home practice:
(1) Receiving objective feedback from a third party to gain a clearer perspective on one's own performance [10].
(2) Assigning homework that is appropriately challenging, considering the student's age, experience, parental support, and skill level [11-12].
(3) Rewarding completed assignments with stickers or stamps to motivate students [13].
These teachers, with their deep expertise, foster substantial musical skills, contributing to students' continued engagement with piano through high school and college.

2.3 Teacher and Student Questionnaires

A questionnaire was set up on the website of the Piano Teachers' National Association to clarify teachers' perceptions and students' actual practice conditions at home. Responses were collected from 81 teachers of various ages, genders, and skill levels. The student survey was conducted through teachers, with 37 students from schools reporting their practice status daily for 1 week using Google Forms.

Teacher Questionnaire: The top concern for teachers regarding students' home practice was "insufficient practice days," accounting for 83% of responses. This was followed by 59% of the teachers indicating that students practicing with incorrect sounds and rhythms was a concern.

Student Questionnaire: The home practice records were submitted via Google Form every day after piano practice.
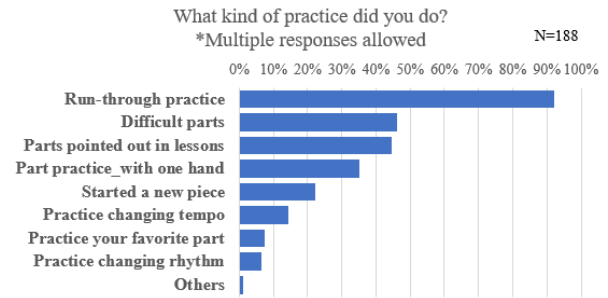

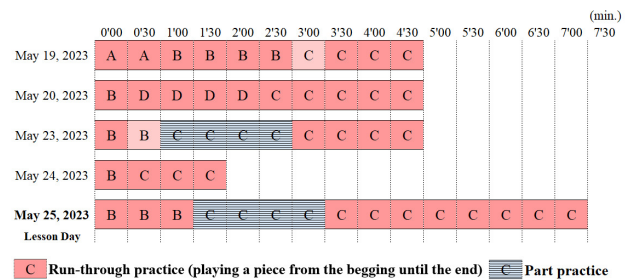**Figure 2.** Survey Results on Practice Content for Elementary School Students.

Figure 3. Timeline of home practice for first graders: most of the time was run-through practice.

Days and duration: Out of the total 259 days surveyed (37 students × 7 days), 250 days of responses were received. The number of practice days was 188, averaging 5.08 days per week per person, indicating that they practice on weekdays. In addition, 69.1% of the respondents (130 out of 188 days) practiced for more than 15 minutes at a session.

Practice content: An analysis of responses (Fig. 2) to questions about actual practice content revealed that 92.0% (173 out of 188 days) of students reported performing "full run-throughs" of pieces from start to finish. However, only about half of the students practiced "partial sections" such as practicing difficult parts (46.3% or 87 days), practicing parts pointed out in lessons (44.7% or 84 days), or practicing with 1 hand (35.1% or 66 days).

The survey results from both teachers and students revealed a gap in their perceptions. While 83% of the 81 teachers surveyed expressed concerns about the insufficient number of practice days, the student survey results showed that students practiced an average of 5.08 days per week, with 69.1% spending more than 15 minutes per practice session. These results highlight a significant discrepancy between teachers' perceptions and the actual practice conditions of students.

2.4 Analysis of Home Practice Videos from Students

Thirty of the students in the study recorded their home practice for the same week and uploaded the video to Google Drive. As a result, a total of 177 days practice videos were collected. These videos were viewed and analyzed by 5 active teachers, with each teacher assigned a different set of videos to review. The analysis was conducted based on a format that included 5 items: timeline, piece, practice sections, practice methods, and free comments, allowing each teacher to record their observations.
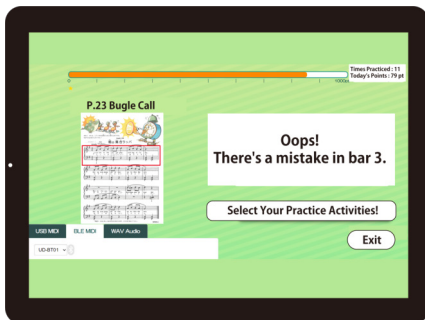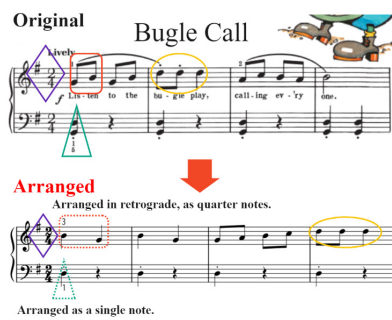
Figure 4. Screenshot of performance assessment.
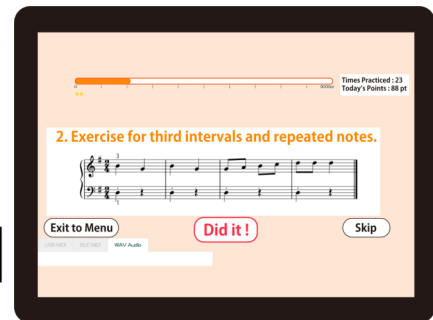

Figure 5. Example of Part Practice Method B

Figure 6. User Interface: students push "Did it !" button after each part practice was completed

For example, Fig. 3 shows a timeline of home practice of first-grade elementary school student who worked on 4 pieces labeled A to D over 5 days of the week. The videos showed the student independently engaging in practice, with a high proportion of full run-throughs in their practice routine. On 1 day, the student repeated a full run-through of the same section 3 times, making the same mistakes each time, but then moved on to the next piece without correcting them. On the day of the lesson (May 25, 2023), the practice time was longer than usual, and the mother's involvement was also observed.

In other videos, various methods of counting the number of plays were observed, such as using an iPad or notebook to keep track, or using educational toys like "Pop-It" to count. There was a tendency to end the practice session after a certain number of repetitions, regardless of whether they could play the sections correctly or not.

Moreover, from the perspective of parental involvement, a correlation was observed between the extent of parental involvement, the completion of assignments, and the students' initiative. Active parental involvement was seen to accelerate technical progress in students, although it tended to suppress their autonomy. While children's skills improved when parents pointed out mistakes in sound or gave prompts similar to those of teachers in lessons, this also led to situations where the child felt pressured and became overly tense. On the other hand, when parents were not overly involved and only supported when prompted by their child, the students tended to practice independently. Although practice often ended based on the number of times played, mistakes sometimes remained uncorrected over time. Furthermore, parents encouraging children to think about the next steps and motivating them through praise and encouragement helped support the children in approaching practice in a relaxed and thoughtful manner.

2.5 Identified Challenges from Field Study

The field study revealed the following challenges: (1) Students themselves find it difficult to objectively view mistakes in sound and rhythm. However, it is challenging for parents, who may not have a deep understanding of piano instruction, to provide appropriate support that is neither too interfering nor disinterested. (2) Merely completing a set number of full run-throughs makes it difficult to overcome sections that are not well-played. (3) There is a gap between teachers' perceptions and the actual practice conditions of students. (4) Rewards are effective in improving motivation, but since they are only received during weekly lessons, they do not easily motivate home practice.

3. SYSTEM DESCRIPTION

Based on the identified challenges in the previous section, a system was designed to enhance the efficiency of students' home practice. The implemented features in this system are as follows:

(A) Providing feedback on whether a performance is correct or incorrect by a third party other than parents

(B) Encouraging targeted practice of difficult sections by segmenting practice pieces [3],[14]

(C) Enabling teachers to review home practice records at any time

(D) Motivating students by providing rewards every time they play their practice pieces, visualizing these rewards

3.1 Overview of the Practice App

To achieve the objectives (A) through (D), we implemented the system as follows. It is important to note that while objective (A) is only accessible to users of digital pianos with MIDI output, objectives (B) through (D) are available for both electronic and acoustic piano users.

(A)Design of Performance AI Assessment by System
The system is designed to allow a third party other than parents to provide feedback on the correctness of a performance.

After selecting the homework piece, the student chooses which section of the piece, previously divided into units of about 4 measures, they wish to practice. They start the performance by pressing the "Start" button. The student's performance is recorded in MIDI and converted into a Standard MIDI File (SMF). The recording is done without a metronome or click track to allow the student to play at their own tempo. The student's performance SMF is then compared with a pre-prepared exemplary performance SMF. As a preprocessing step before comparison, the note ON events in the SMF are sorted chronologically. Note ON events within 50 ms of each other are considered

simultaneous and are sorted by MIDI note number in ascending order. The preprocessed SMFs are compared using Dynamic Programming (DP) matching [15] to find corresponding notes between the student's performance and the exemplary performance, and any discrepancies are detected as mistakes. Since this is intended for beginners, a simple method like this is sufficient for now. However, using symbolic music alignment instead of DP matching is a subject for future consideration.

If the performance is flawless, the system responds with "Well played!" If there are mistakes, the system points out the first bar where a mistake occurred (Fig. 4).

(B) Design for Segmenting Practice Pieces
Video observation of home practice sessions revealed that it is difficult to compensate for mistakes and weaknesses by simply practicing through the piece. Therefore, we aimed to encourage segmented practice in order to improve overall mastery of the piece.

Students select their homework piece and, after receiving system feedback on any 4-bars block, they can choose to work on segmented practice pieces using 1 of following 2 methods:

Part Practice Method A: Simplifies the homework piece by concealing parts of the score every 4 measures. This method aims to focus on specific sections by maintaining the original sheet music's staff lines, bar spacing, and notehead sizes, while intentionally hiding parts to help students focus on particular areas.

Part Practice Method B: This method involves identifying key learning elements that are either crucial for learning or where many students stumble. Short 4-bars pieces, simpler than the original, are composed that include some of these learning elements (Fig. 5). The contents were composed by 6 music majors, including three active piano instructors. The following conditions apply to the composition process [16]:

#1: Include at least one challenging learning element from the original phrase.

#2: Maintain the same time signature, position, and key as the original phrase.

#3: Include fewer learning elements than the original.

#4: Maintain or lower the level of learning elements. Lowering is defined as reverting to already learned related elements.

#5: If using elements other than melody and rhythm, employ the same starting note, melody, and rhythm as the practice phrase from the original.

#6: Use a melody that the students may have heard before.

In both Part Practice Method A and B, students can either play the presented 4-bars practice piece or choose to skip it by pressing the skip button located at the bottom right of the sheet and move on to the next original practice piece.

(C&D) Design of Monitoring and Rewarding
Instead of teachers assessing students' home practice solely based on their performance during weekly lessons, the design allows teachers to continuously check daily and cumulative practice time since the start of using the Practice App, the number of times practice pieces are played, and the points earned.

The rewarding design: 1 point for just logging in, 1 to 5 points for pressing the "Did it!" button (Fig. 6), and 10 to 50 points awarded by teachers as a reward. The educational philosophy of this system is "from result-oriented to process-oriented." In a result-oriented approach, perfect performances evaluated by the AI performance assessment would likely earn higher points. However, in a process-oriented approach, value is found in the attempt itself, and regardless of the performance outcome, a consistent 5 points are awarded. Thus, these experimental results are evaluated without a strong AI performance assessment component, other than the simple pitch errors.

3.2 Overview of PoC (Proof of Concept)

Students participating in the PoC were recruited via the website of an organization for piano teachers. The PoC is not an independent experiment but is incorporated into actual students' regular lessons and practice. Participants were selected based on their responses to questions about teaching materials, instruments owned, and devices owned. Additionally, 30 tablets for the PoC were lent out, and it was anticipated that students would use devices (tablets, smartphones, computers) alongside their usual sheet music.

For the performance assessment feature, students who mainly use digital pianos at home were targeted, although some students with acoustic pianos were also accepted. The teaching materials used were "Bastien New Traditions: All In One Piano Course - Level 1A" and "Bastien Piano Basics [17]: Piano - Level 1," both of which have been translated into over 16 languages worldwide.

The PoC was conducted from October 2023 for 4 months. Piano students using the Practice App were introduced by their teachers, and the teachers' surveys were linked to individual students for analysis. To validate the Practice App, a pre-assessment questionnaire was conducted at the beginning and a post-assessment questionnaire after 4 months.

3.3 Results of System Usage

3.3.1 Period and number of participants

Students who participated in the PoC were referred by 46 teachers, and 80 students used the Practice App at least once. The age of the students mainly ranged from first to third grade of elementary school, with a few preschoolers and fourth to 6th graders included. The number of days the Practice App was used ranged from a minimum of 1 day to a maximum of 117 days, with an average usage of 39.2 sessions. The Total points, indicating the level of activity in using the Practice App, ranged from a minimum of 5 points to a maximum of 8,628 points, averaging 1,399 points. 36 teachers monitored their students' practice sessions at least once using the Practice App.

3.3.2 Comparison of Pre/Post PoC Questionnaire

The same questionnaires were administered to students before and after the PoC to validate the effectiveness of the Practice App. The questionnaires used a 5 level Likert scale to ask about students' attitudes towards piano practice and their parent-child relationships. The responses were based on the respondents' subjective perceptions of these aspects. 52 students responded to both the pre and post questionnaires. The students who earned more than 1,000

Questionnaire for HPG Students	Mean	
	before	after
Does your child enjoy daily practice? **	3.20	3.64
Is your child self-motivated in daily piano practice? **	2.76	3.52
How long do you practice each day? *	3.12	3.52
How do you feel about your relationship with your child during daily piano practice?	3.16	3.24

Table 1. Paired t-test of Pre- and Post-PoC Questionnaires for HPG Students (N=25, **p<0.01, *p<0.05)

points with the Practice App were categorized as the High-Practice Group (HPG) with 25 students, and those who earned less than 1,000 points were categorized as the Low-Practice Group (LPG) with 27 students. For the group of 25 HPG participants, a paired t-test was conducted on the pre- and post-assessment questionnaire results. As shown in Table 1, significant improvements were observed in Daily Practice Time, Voluntariness in Practice, and Enjoyment of Practice. However, no significant effect was observed in improving parent-child relationships.

3.3.3 Validation by questionnaire after PoC

Responses to questions included only in the post-PoC questionnaire were collected from 64 participants. These were divided into two groups: 30 in the High-Practice Group (HPG) and 34 in the Low-Practice Group (LPG). The average scores for HPG were listed in descending order in Table 2. Independent sample t-tests were conducted for each question.

In the HPG, half of the 14 question items averaged 4.0 points or higher. Furthermore, HPG received significantly higher scores than LPG in 9 out of the 14 questions. The item "Increased Voluntariness for Practice" in Table 2 corresponds to "Voluntariness in Practice," which showed significant effects in the paired t-test described in previous section. Therefore, even though there were no significant differences found in the independent samples t-test for items like "Motivated by 'Did it!' Button," "Supported by AI performance assessment," and "Supported by Part Practice Method A," the higher scores in "Increased Voluntariness for Practice" suggest that system was effective. Thus, it is estimated that the system influenced 13 out of the 14 items.

3.3.4 Results of the Teacher Questionnaire

After the PoC, feedback was obtained via a Likert scale questionnaire from 46 teachers, as shown in Table 3. An independent samples t-test was conducted between 26 teachers (HPG) who had at least 1 student scoring over 1,000 points and 20 teachers (LPG) who did not.

Out of 15 questionnaire items, 7 averaged 4.0 points or higher. Moreover, HPG received significantly higher responses in 10 items compared to LPG. The item "Have Students Use Part Practice Method A" scored particularly high for HPG at 4.69 points, with a significant difference from LPG. Conversely, "Have Students Use Part Practice Method B" was the only item among all 15 where both HPG and LPG teachers scored above 4.0 points. Significant responses were also seen in items relating to teacher

Questionnaire for Students	Mean	
	LPG	HPG
Did tracking practice motivate you? **	3.59	4.30
Did Method B support your practice? **	3.50	4.29
Did the "Did it!" button motivate you?	3.76	4.27
Did AI assessment support your practice?	3.67	4.27
Did Method B support your practice?	3.55	4.12
Did practice points motivate you? *	3.41	4.10
Did practicing become more enjoyable? **	3.15	4.00
Did your practice time and frequency increase? *	3.06	3.83
Did your piano skills improve? **	2.85	3.70
Did using Practice App motivate you? **	2.82	3.60
Did it reduce the burden on parents? *	2.85	3.60
Practice independently without parents? **	2.71	3.53
Did your motivation for practicing increase?	3.09	3.43
Did your teacher give you a passing mark earlier?	2.68	3.20

Table 2. Results and Mean Values from Independent Samples t-Test of Post-PoC Student Questionnaires Between HPG and LPG (N ranges from LPG: 9-34, HPG: 11-30, **p<0.01, *p<0.05)

Questionnaire for Teachers	Mean	
	LPG	HPG
Do you want students to use Method A? **	3.85	4.69
Did it spark home practice talks with students? **	3.30	4.42
Do you want students to use Method B?	4.15	4.38
Was Method B effective in improving sight-reading skills? *	3.95	4.38
Any insights from checking students' practice amount? **	3.20	4.27
Any positive changes in students? **	3.25	4.19
Did it help observe students' home practice? **	3.30	4.00
Did lesson efficiency improve? **	3.00	3.92
Did it lead to better lessons?	3.35	3.85
Did students' performance improve by the next lesson? **	2.85	3.85
Did students' sight-reading improve? *	3.20	3.73
Did it change how you assign homework?	3.15	3.65
Did AI assessment reduce pitch and rhythm mistakes?	3.05	3.54
Did points awarded by teachers motivate students? *	2.75	3.50
Did it increase the number of assigned pieces?	2.90	3.23

Table 3. Comparison of Mean Values Between Teachers with 1 or More Students in HPG and Those Without (N=LPG: 20, HPG: 26, **p<0.01, *p<0.05)

engagement with home practice, such as providing opportunities for discussions about home practice and observing the process.

The questions "Have Students Use Part Practice Method A," "Have Students Use Part Practice Method B," and "Part Practice Method B is effective for reading skills" reflect teachers' opinions on the functionality rather than the change in students due to implementation, which might explain the higher scores from LPG. As a result, while "Have Students Use Part Practice Method B" did not show a significant difference in scores between HPG and LPG, the high average score of 4.38 points for HPG indicates substantial positive expectations from the teachers.

3.4 Summary of Results

Results from section 3.3.2 indicated that there were significant differences in the Likert scale questionnaire scores

before and after the start of the PoC, demonstrating improvements in "Daily Practice Time," "Voluntariness in Practice," and "Enjoyment of Practice."

From section 3.3.3, significant differences between the High-Practice Group and Low-Practice Group in the post-PoC questionnaire suggest that motivation for practice, practice time and frequency, and the sense of improvement increased while reducing parental burden. Items that scored an average of 4 points or higher in the HPG are considered to indicate the effectiveness of the Practice App. According to the results from section 3.3.4, the significant differences in scores between the HPG and LPG indicated an increase in teachers' awareness of home practice. Both Part Practice Method A and B being highly rated by both groups indicates that these methods are perceived as effective practices by teachers and hold high expectations.

4. DISCUSSION

4.1 Factors Enhancing Engagement

Motivational Effects: The visualization of the effort process has been shown to be effective in motivation in other studies as well [18], but this time, visualizing the efforts of child students at home practice with points confirmed significant motivational effects. For example, a second-grade elementary school monitor student practiced a song from the introductory tutorial book 3 times through, totaling about 2 minutes of practice before the PoC in October. However, two months after starting to use the Practice App, the student began practicing more than 30 minutes every day and was able to progress to "Burgmüller: 25 Progressive Etudes, Op. 100"[19]. This substantial change in motivation was attributed to daily point rewards by teachers, as revealed in interviews. The total points, including both self-reward points and teacher reward points, were always displayed. Students who noticed the addition of teacher points showed increased motivation. Moreover, segmenting practice pieces and increasing the frequency of pressing the "Did it!" button increased opportunities for earning points, enhancing students' autonomy and providing a game-like experience. This led to an increase in frequency and duration, thereby improving sight-reading skills.

Analysis of Part Practice Methods A and B： Field studies show that teachers have traditionally assigned students to practice with one hand or rhythm practice as homework [20], using methods such as writing instructions on the score or using sticky notes. However, in Part Practice Method A, for example, when practicing only with the right hand, the system hides the left-hand part, allowing focus solely on right-hand practice. The system displaying only the part being practiced helps students concentrate on the task without being distracted or overwhelmed by having to cognitively process the whole score first and subsequently disregard some parts. This focus on individual tasks was perceived as effective based on questionnaire results and post-interviews with teachers. Part Practice Method B is not just a specialized part-practice for the assigned homework piece but focuses on learning elements intended to be acquired in that piece, aimed at improving sight-reading skills overall. Interviews and questionnaires

with teachers suggest that compared to adult students aiming to master specific songs, there is a high expectation for child students to improve their sight-reading skills overall to play many pieces in the future.

Feedback and System Impact: In the free-response section of the post-use survey, both students and parents shared feedback such as, "It was helpful that the AI performance assessment could identify mistakes even when parents couldn't supervise the practice," and "Knowing that the teacher was monitoring daily practice motivated the child (student)." Teachers also provided positive feedback, saying, "The system's suggestion for part practice helped students who tend to play through the entire piece from start to finish to adopt sectional practice," and "The presence of the system as a third party seemed to reduce parents' frustration." These responses aligned with the goals of our study, indicating a successful outcome.

4.2 Limitation

This study primarily aimed to conduct a PoC; hence, for the performance assessment, it did not involve using acoustic pianos with automatic musical acoustic alignment [21-24], but instead conducted validations using digital pianos, which offer higher recognition accuracy. Although the effectiveness of segmenting practice pieces was confirmed, the study did not perform detailed analyses such as comparing the impact of Part Practice Method A and B separately or comparing the effects of practice with and without segmentation. The interface was changed to English for the paper, but we use Japanese in practice. Additionally, feedback indicated the current teacher UI is difficult to use in multi-student classrooms. This suggests the need for UI improvements to reduce management costs for actual classroom deployment. Furthermore, while the study has statistically summarized outcomes, reports indicate that some students felt monitored during home practice, and it has not been possible to perform usability evaluations that consider such individual differences.

5. CONCLUSION

This study, through a large scale field study of piano teachers and students, revealed that the challenges in children's home piano practice include not recognizing errors in playing without parental support, repeating inefficient full runthroughs, teachers not understanding the practice process, and maintaining motivation. To address these problems, a system was developed incorporating performance assessment, presentation of segmented practice pieces, reports to teachers, and point allocation, and a PoC was conducted. The results confirmed that (1) the system identified mistakes, reducing parental burden, (2) increased practice time and improved sight-reading skills, (3) increased awareness among teachers about the practice process, and (4) enhanced student motivation and spontaneity. These outcomes suggest that the proposed system has the potential to enhance efficiency and effectiveness in children's piano learning. Challenges such as individual differences in UI and usability, as well as environmental settings, remain for actual deployment and are targeted for future work.

SUPPLEMENTAL MATERIALS

All supplementary materials are available in "https://prim.piano.or.jp/supplementary/ISMIR2024.html"

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