EnseWing: Creating an Instrumental Ensemble Playing Experience for Children with Limited Music Training

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ABSTRACT
While instrumental ensemble playing can benefit children's music education and collaboration skill development, it requires extensive training on music and instruments, which many school children lack. To help children with limited music training experience instrumental ensemble playing, we created EnseWing, an interactive system that offers such an experience. In this paper, we report the design of the EnseWing experience and a two-month field study. Our results show that EnseWing preserves the music and ensemble skills from traditional instrumental ensemble and provides more collaboration opportunities for children.

Author Keywords
Children, instrumental ensemble, collaboration, music

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Instrumental ensemble playing can help to develop children's collaboration and coordination skills because good and harmonious ensemble music can only be delivered through flawless coordination among various instrumental parts. However, to play in an ensemble, a child must have received sufficient musical training and be proficient in at least one instrument. Therefore, we created an interactive instrumental ensemble system called EnseWing to help children with limited music training experience ensemble playing. EnseWing retains the key characteristics and challenges of instrumental ensemble playing, but replaces musical instruments with an intuitive gestural interface, thereby removing the barrier of instrument proficiency. We conducted a two-month field study and found that EnseWing can help to develop children's musical and ensemble skills effectively and can enhance collaboration.

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RELATED WORK
Dalcroze Eurhythmics argued that the body should be the first instrument to be trained, since kinesthetic learning and music can reinforce each other [16, 18]. The brain memorizes, determines, and corrects movement patterns while the body moves with the music. The Orff Approach [13, 15] also indicates that kinesthetic learning can facilitate a person's music perception, body coordination, and creativity, and childhood is the best time to develop a sense of rhythm through body movement.

According to Bakker et al. [7], embodied metaphors could help children understand music concepts. Thus, some music systems have leveraged motion-sensing technology to enable music creation for children. For example, BodyBeats [20] allows children to trigger preselected audio using whole-body interaction, and MoBoogie [12] enables children's creative expression by changing music through body movement.

Researchers have used music to enhance collaboration skills. Various systems have been developed to help children collaboratively play instruments with instrument icons that are mapped to an interactive desktop [14], to produce musical rhythms through coordination among multiple participants [8], to help novices and amateurs compose music [10], to facilitate classroom music education with a collaborative mobile app [19], and to provides collaborative musical improvisation on a tabletop surface [9]. Similar concepts have been applied to video games, such as Rock Band[3] that allows players to perform music together, and Wii Music[5] that lets players control an on-screen band. However, most of these video games support the collaboration of different instrumental parts via beat matching instead of performing.

It is rare to see research with a focus on simulating a real-world instrumental ensemble experience for children. PLOrk [2] and SLOrk [4] explored the possibility of computer-mediated ensemble playing, but both were designed for experienced performers. To our knowledge, our research is one of the first attempts to enable children with limited music training to experience an instrumental ensemble and to gain a sense of cooperation through ensemble practice.

ENSEWING

Initial Investigation & Design Principles

We interviewed two conductors of a children's brass band in China. Each interview was semi-structured and 90 minutes long. According to them, it usually takes a child at least 18 months of music training (including both instrument and ensemble training) to be ready for an ensemble. They listed five essential elements of ensemble and primary challenges. 1) Pitch: taking wind instruments as an example, children need to learn embouchure, breathing, and fingerings to produce correct notes. 2) Rhythm: many children cannot master the duration differences between eighth notes/rests, quarter notes/rests, etc. 3) Tempo: all players should follow the same tempo, but children often rush or drag. 4) Volume: the volume of each instrument needs to be finely controlled –being loud as a leading part at one moment but soft as a supporting part at another. 5) Cueing (Time-to-enter): different instruments often enter at different times and may need to stop and re-enter in the middle of a piece.

While all these elements are developed in instrumental ensemble training, pitch is the most relevant element to musical instrument training. It takes the most practice time for a beginner, but the developed skill is not directly transferable between instruments. The other four elements are essential to coordination among musical parts in a harmonious ensemble and are common across instruments. Therefore, we proposed two design principles: simplifying instrument learning with simple gestures and no pitch control and keeping the main challenges from ensemble rehearsal and performance: rhythm, tempo, volume, and cueing.

Design & Implementation

We used the participatory design method involving a conductor and six children, who also participated in our field study. We tested the first prototype for two days (90 minutes per day) in an elementary school in Beijing and subsequently improved the design based on our observations. The final design is presented as below.

Interaction/Music Control: Children control music using a hand-worn gyro/accelerometer that senses horizontal motion and a Kinect that senses vertical location. Similar to [12], the pitch of each note is pre-programmed in sequence, so the children do not need to control it. Children can move a hand horizontally to start playing. The rhythm and tempo are embodied through the control of each note. Children can play each note by moving a hand horizontally. A note keeps playing until the hand movement is reversed, at which point the next note starts to play. If the hand is held still, then the current note plays continuously. For volume control, the higher the hand is lifted, the greater the volume.

User Interface: EnseWing uses a visual symbol, "music bone," to illustrate note pitch and rhythm (Figure 1) and to facilitate the understanding of abstract music concepts. The height of a music bone represents the pitch of a note, and the length represents the duration. The music bone of each note turns red as it is being played. We also added numbered musical notations, which are widely used in China.

Function: EnseWing has common media player functions, such as play, pause, and restart. To facilitate practice and rehearsal, we also added "practice phrase" and "practice whole song" buttons to strengthen the control of rehearsal.

Figure 1. User interface of EnseWing.

The interface described is an individual interface. The actual EnseWing experience comes into existence when all participants, including the conductor and the children, use the system in the manner of a real ensemble.

FIELD STUDY

We deployed EnseWing in an elementary school in Beijing and included six children in the study (Table 1). Each child chose one of six instrumental parts of an ensemble. A music teacher, who was also the conductor of the school chorus, was invited to be the conductor for the study. Her role was very similar to that in a traditional student ensemble. She explained basic music concepts and music pieces to children, planned their training according to their progress, and, most importantly, directed the ensemble rehearsal where detailed coordination was coached to reach harmony. The ensemble class had 14 90-minute sessions in two months and ended with a performance for their parents.

ID	Age	Gender	Instrument Experience	Ensemble Experience
C1	10	M	Keyboard (6 months)	No
C2	10	F	No	No
C3	9	F	Yangqin (4 years)	No
C4	9	F	No	No
C5	10	F	No	No
C6	9	M	No	No

Table 1. Children involved in the field study.

Figure 2 shows the classroom setup. Each child had a working EnseWing interface and a speaker that produced the sound. The sound of each instrumental part was spatially tied to a player just as it would be in a real instrumental ensemble. This aspect was crucial to participants' awareness of each other's parts. Three music pieces were used, "*Doll and Bear Dancing*", "*Twinkle, Twinkle Little Star*", and "*Canon*", with instrumental parts composed specifically for EnseWing.

All sessions and the performance were video recorded. At the end of each session, we conducted interviews with the conductor and the children. We also interviewed the parents after the final performance. All interviews were transcribed.

Figure 2. Setup of the class using EnseWing.

We analyzed all videos using a video coding tool, Datavyu[1] with two coders. One coder participated in the study, and the other was experienced in instrument performance and chorus. We conducted a 4-week coding cycle with the coding methods in [6, 11]. Every week, the two coders reviewed the videos of the same sessions, and then the coders and the researchers discussed and refined the codes. In the coding iterations, an important agreement among coders and researchers was that obtaining awareness and acquiring skills should be separated. In all, seven codes were collected from the videos, and three more codes were generated from similar iterative coding of the interviews. The constructed ten codes can be put into four categories: music awareness and skills, instrumental ensemble awareness and skills, collaboration, and overall experience (Table 2).

EXPERIENCE

We received positive feedback from the children and the conductor. The children reached basic ensemble performance level with EnseWing within two months. Video analysis results are summarized in Figure 3.

Music Awareness and Skills

Session 1 to session 5 mainly focused on training individual music awareness and skills. By session 10, all children could learn their instrumental parts of a new music piece within 45 minutes, which significantly shortened the preparation time.

Rhythm Awareness (A1): The children developed their sense of rhythm through singing with the piano, following the conductor, and pair-wise practice. Pair-wise practice significantly accelerated the learning process. All children got the rhythm awareness in Session 6.

Rhythm Skills (A2): Through repeated practice, all the participating children mastered how to map their movement to the rhythm within five sessions. All the children obtained rhythm skills first and then developed a sense of rhythm, which is consistent with the theory that children could obtain rhythm sensation through kinesthetic learning [16, 18].

Understanding of Instruments (A3): In EnseWing, songs have six instrumental parts. For example, "Twinkle, Twinkle Little Star" had piccolo, organ, oboe, piano, string ensemble legato, and vibraphone. The children could not distinguish every instrument in the end, but they figured out that the instrument for each part is different and became very interested in distinguishing the difference.

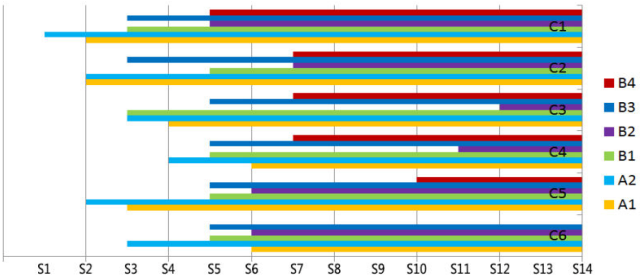

Figure 3. Video analysis of music and ensemble awareness and skills (C - Children, S - Session).

Instrumental Ensemble Awareness and Skills

All the children had no previous ensemble experience. Their ensemble awareness gradually evolved throughout the study. In the first five sessions, the children showed little ensemble sense. However, through spontaneous pair-wise practice from session 6 to session 9, children became aware of their own role, the other parts, and the relationship between them.

In session 10, the conductor helped the participants to coordinate their playing and learn how to allocate auditory attention to their own part, other parts, and the metronome simultaneously. Next, children were taught to understand the conductor's gestures as a replacement for the metronome. Children learned how to distribute visual attention to the conductor and the music scores on the screen (Figure 4b), as well as auditory attention to their own part and the other parts. These ensemble skills developed during our field study were consistent with the skills developed in a traditional instrumental ensemble.

In the later sessions, children were able to clearly describe the structure of the music and the relationship among the

Label	Code	Observation	Source
A. Music awareness and skills			
A1	Rhythm awareness (sense of rhythm)	Wave the arm steadily when practicing his/her part independently	V+I
A2	Rhythm skills (body movement with rhythm)	Wave the arm steadily by following the conductor/ metronome	V+I
A3	Understanding of different instruments	N/A	I
B. Concert awareness and skills			
B1	Awareness of the conductor	Glance at the conductors' hand gestures frequently	V+I
B2	Following the conductor	Follow the tempo and start/stop cueing based on her hand gestures	V+I
B3	Awareness of the other parts	Notice the screen and the other parts' movements	V+I
B4	Collaboration with the other parts	Keep the correct rhythm when coordinating	V+I
B5	Overall understanding of the ensemble	N/A	I
Collaboration		Collaboration in pairs, between parts, and in the group	V+I
Overall Experience		N/A	I

Table 2. Codes generated from videos and interviews. V-Video analysis; I-Interview

Figure 4. (a) Pair-wise practice. (b) Following the conductor.

various parts, which contrasts to not caring about other parts in the beginning of the study period. Throughout the class, the children's attitudes towards collaboration awareness changed significantly.

> *C1: "At first, I had no idea about the role of other parts, but gradually I understood it. I think parts one, two, three and four are the primary parts, and parts five and six are supporting roles. I take part six as a reference of accent."*

Awareness of the Conductor (B1): Awareness of the conductor was determined by if a child look at the conductor's gestures consciously and actively. Two children (C1, C3) acquired the awareness in session 4, and others in session 6. The teacher's conduct and the use of a metronome deepened the children's understanding of rhythm, so they started to look at the conductor consciously to follow the rhythm. On the day of session 6, the teacher asked the children to stop using music scores and computers and wave their arms in front of the mirror with only the melody and the conductor to follow.

Following the Conductor (B2): C1 acquired this skill in session 6; C5 and C6 in session 7, C2 in session 8, C3 in session 11, and C4 in session 12. Skill acquirement times were scattered through session 6 to session 12, but all the participants acquired the skills after they became aware of the conductor. After the children followed the conductor consciously, they would match their own tempo with the conductor. Through self-practicing, playing with companions, and following the conductor, the children were able to gradually acquire the necessary skills.

Awareness of the Other Parts (B3): C1 and C2 obtained this awareness in session 4, but most children got this in session 6. During session 6, the conductor asked the children to stand in front of a mirror to sing their melody separately, and then one child played by his/her part, with the other children playing along with him/her. In this cooperation, the children increased their awareness of other parts. After this day's training, all students acquired the awareness of other parts. Practicing in pairs raised the tacit understanding between the children [17]. They could understand and analyze the music score rhythm of each other's parts. In the interview, C3 told us, "I found that my rhythm is exactly the same as C6."

Collaboration with the Other Parts (B4): Cooperation skills were developed when children played with the other parts. They could play their own part with a steady tempo, and did not play out of tune. C1 acquired this skill in session 6; C2, C3, C4, and C6 in session 8; and C5 in session 11. Most children acquired the skill in session 8, mainly for two reasons. First, from session 6, cooperation between each group of two children increased. Through repetitive practice, their cooperation skills improved. Second, in session 8, the conductor played the melody of both parts with a piano so that the children could learn the sound between parts.

Overall Understanding of the Ensemble (B5): As the training of instrumental ensemble continued, the children gradually learned the purposes of the different parts and obtained a general awareness and the ability of judgment.

> *C4: "When I listened to the second line of the score, I knew that if the sound of the six parts sounded like one person, we have played the melody right."*

Collaboration

Children offered help if others could not follow the pace. For example, in session 10, a boy had trouble with controlling the gestures. A girl who was good at it helped him (Figure 5a). In Session 11, when a girl had trouble with the rhythm, all the others gave up their break time and actively helped her (Figure 5b). Similar cases became frequent in the later stages of the class.

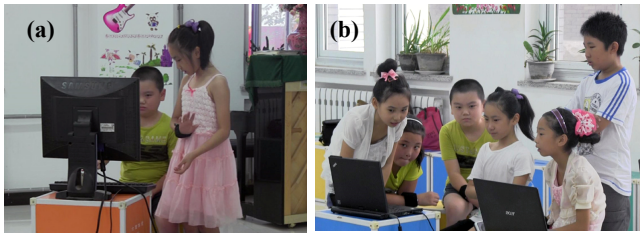

Figure 5. Children help others in (a) gesture controlling and (b) rhythm understanding.

EnseWing provided new collaboration opportunities for children. Because the simple gesture control replaced playing a musical instrument, the children could use this method to control rhythm and volume as well as learn tempo and cueing. In a traditional ensemble, it is more difficult for children to help each other play different instruments.

CONCLUSION

We presented EnseWing, an ensemble experience for children with limited music training. The key to EnseWing is not the technical perspective, but how the system enables the conductor and untrained children to emulate a real ensemble experience. All participants act as co-creators of the experience by "enacting" it. We found that the embodied music control in EnseWing also enables collaboration between children, since the gesture is the same across different instrument parts and is explicit to be observed. Additionally, the intuitive interface with the "Music Bone" design helped the participating children easily understand the music concepts. The simple gestures significantly contributed to children being able to accurately play note durations. We hope that these findings will help other researchers to design similar systems. In the future, we plan to perform longer and broader deployments, and we will investigate the long-term effects of EnseWing in promoting collaboration awareness beyond the ensemble itself.

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