Mobile Device Applications for Head Start Experience in Music

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Abstract. This research intends to develop music games as mobile device applications on android system for head start experience in music. The study of design content includes the perception, knowledge formation, musical knowledge and ability, and children's play and learning motivation. 8 mobile device applications across two levels have been created and 4 of the first game level are tested by 21 preoperational children. In the latter part of this qualitative research, researchers collect data from participants' observation, video recording, and tablet input data records. The credibility and validation study consisted of two steps: analyzing and comparing 3 dimensions of attitude, interaction, and problem solving of collected data.

Keywords: Musical game · Multi-touch applications · Qualitative research

1 Introduction

To study musical game design principles, this research developed a test using multi-touch applications. In previous explorations of educational theories and music teaching methods, Chung [1] summarized important considerations for designing musical serious games: (1) pre-operational children can only perform certain cognitive functions, such as, differentiating, classifying, sequencing, egocentric representation thinking, and lack cause-effect reasoning abilities; (2) musical development in pre-operational children consists of sensing steady beats, pitch degrees and intervals, and to assess musical knowledge and representation through music activities (singing with movements, performing, improvising, conducting, and so on); (3) the preference of teaching contents and materials is sequential learning of rhythmic and melodic patterns, pentatonic scales, and folk songs/tunes.

To study the assessment of young children in musical game playing, the researchers developed 8 nonconsecutive applications over 2 levels to provide the experience and challenges of musical elements appropriate for the age range. The tested subjects were 21 children of ages 4 to 5 years old. Over the course of 10 weeks, 15 min sessions, once a week, were conducted for each child. During testing, the researchers made observations of the participants, collected video recordings and tablet input data records for analysis and discussion. To confirm the credibility and validity of this testing, we hired two graduate students as coders to perform the analysis on three dimensions: attitude, interaction, and

A.L. Brooks and E. Brooks (Eds.): ArtsIT/DLI 2016, LNICST 196, pp. 189–196, 2017.
DOI: 10.1007/978-3-319-55834-9_22

problem solving. Their analysis extended to sub-items including: active/passive, interested/non-interested, emotional expressions, physical/verbal responses to visual/auditory cues, and exploring possible gameplay/inquiring for answers to problems. Furthermore, we examined and compared their analysis results. The following sections review the literature related to this research, development of musical applications on mobile devices, analysis and comparison results of two coders, and a conclusion.

1.1 Perception and Musical Ability

In the research of synchronization of beats, preparation, and attention, "tapping" is the most accurate practice of playing or keeping steady beats [2–5]. Humans tend to hit 20 to 60 ms earlier than the constant beats of the duple meter due to the sense of balance [6]. Accents appear to help in accurately executing steady beat tapping [7].

Humans possess auditory as well as visual perception abilities to easily differentiate melodic patterns (Gestalt theory). Melody is constructed by successive pitches with shapes and directions. Humans can also perceive melodic figures (musical themes) and background (instrumentation/orchestration), which are not necessarily true to different octaves. On the contrary, within an octave, the Gestalt principles function well on proximity, similarity, good continuation and coherence [8]. Without any musical training, 6-year-old children are no different from 11-year-olds in perceiving musical sound including the main melodies accompanied by the harmonic progressions [9].

1.2 Knowledge Formation and Musical Knowledge

The formation of knowledge requires perceptual experience to make sense of daily activities [10]. Based on Croce [11], the hierarchy of knowledge is formed through the sensory impressions and intuitive knowledge to reach logical knowledge. Croce assumes that logical knowledge continues to accumulate through intuitive knowledge linked by dynamic forms, images, and multiple representations. Thus, the intuitive knowledge is the core transformation between perceptions/sensory impressions and significant meanings/logical knowledge in the human brain.

The above analysis of how humans acquire knowledge is similar to Bruner's knowledge mapping [12]. Bruner believes that sensation, intuition, and analytic knowledge represent the knowledge system of human reality: the *enactive* (sensation), the *iconic* (image thinking), and the symbolic (abstract thinking, reflecting, and communicating).

1.3 Children's Play and Learning Motivation

A sense of competence and self-efficacy is related to a child's value of an activity [13]. According to Flow theory, the equal activity levels of challenge and self-perceived competence will most likely engage children in efficient learning [14]. While children's play may not ensure successful learning in school, it certainly offers possibilities of learning [15]. Children in play are observed to be relaxed and in pleasure. Matching challenge in gameplay to pre-operational motor skills motivates children's exploration in musical play activities.

2 Developing Musical Applications on Android System

Through applying the above theories in pre-operational children, the musical activities provide a head start and prepare children to assess their knowledge and abilities in music. Such musical applications should consist of an optimal selection of age range appropriate content, and interactivity integrated with musical activities. The next two sections discuss the design of selected musical contents, and their multi-touch interactions on the android system.

2.1 Musical Contents

To expose musical concepts to pre-operational children, we selected steady beat tapping, two-pitch interval matching (on a rainbow ladder as 7 bottom-up steps to represent the 7 tones in an octave scale), up/down scales, and pentatonic bubble improvisation for the first level. The advanced level is constructed with more advanced contents of the consonant/dissonant interval of seconds and thirds, musical form creation, and melodic pattern improvisation. The second level could be challenging for pre-operational children. These games should comply with perceptual abilities, cognitive development, knowledge forming process, and music teaching method. Beyond theoretical considerations, the intention was to engage children continuously with gameplay and creative activities, such as, pentatonic tones and melodic pattern improvisation.

2.2 Multi-touch Application and Interactivity

A multi-touch application developed with ADOBE FLASH on the Android system motivates human-computer interaction by single/dual/multi-touch of tapping, pinching, swiping, wobbling, and shaking. It not only substitutes for keyboard and mouse but also offers direct manipulation in interaction with a computer interface. Through detecting the deficiency of multi-touch technology on the Android system (swiping and pinching) and pre-operational children's incompatible sensorimotor skills (eye-hand coordination and

Table 1. The list of multi-touch interactions designed for each game

Game level	Game interface	Musical contents	Multi-touch interaction/s
1	Bouncing Penguin	Steady beat tapping	Tapping
1	Rainbow Ladder	Pitch/interval matching	Tapping
1	Rolling Ball	Up/down scales matching	Wobbling
1	Ocean Bubbles	Pentatonic Improvisation	Tapping
2	Hopscotch	Intervals of seconds and thirds	Single/dual touch
2	Tetris	2nds/3rds matching	Tapping
2	Diamond Beading	Musical form construction	Swiping
2	Ocean Bubble Links	Melodic pattern improvisation	Tapping

hand-finger gestures), we integrated the age range appropriate musical contents with compatible sensorimotor skills for multi-touch interactions. Table 1 displays the multi-touch interactions designed for each game interface.

3 Qualitative Research on Music Games

Qualitative research usually requires long term development, elongated schedule arrangement, and mandatory codes of ethics governed by the Ministry of Science and Technology in Taiwan. We have tested 21 subjects in a private kindergarten. We have only finished the first testing of 4 musical applications of the first game level. Two of the subjects have been through a second testing with satisfactory results. Through careful examining the collected data and discussions, we conducted the analysis on three dimensions: attitude, interaction, and problem solving in accordance with sub-items: passive/active, interested/non-interested, emotional expressions, physical/verbal responses to visual/auditory cues, and exploring possible gameplay/inquiring for answers to problems. The following figures display 4 musical applications from level 1 and the results of analysis and comparison between coder 1 and coder 2 (graduate student researchers).

Remark 1. The representative codes used in the following figures are: SN-Number of Subjects; a1-Active; a2-Interested; a3-Emotional expression; i1-Physical response; i2-Verbal response; i3-Response to visual/auditory cues; p1-Exploring possible gameplay; p2-Enquiring for answers to problems; C1-Coder 1; C2-Coder 2.

We first noticed that (a) and (b) in Figs. 1, 2, and 4 have the most similar analysis; and (c) in all figures have significantly opposing results. The verbal interactions were most preferred in 4 games.

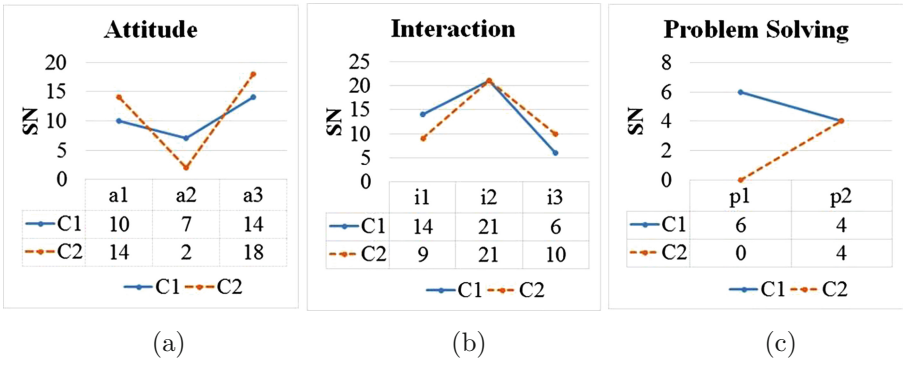

Fig. 1. Bouncing Penguin: analysis and comparison of 3 dimensions as (a) Attitude; (b) Interaction; and (c) Problem Solving.

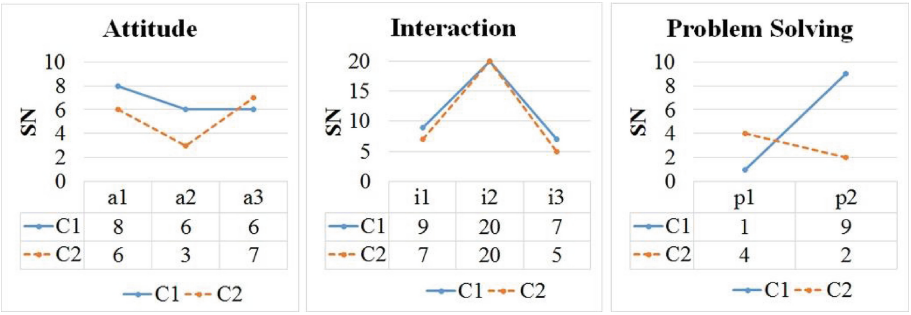

Fig. 2. Rainbow Ladder: analysis and comparison of 3 dimensions as (a) Attitude; (b) Interaction; and (c) Problem Solving.

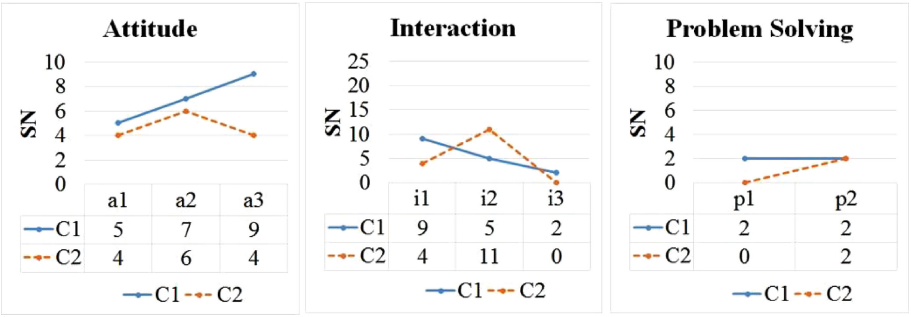

Fig. 3. Rolling Ball: analysis and comparison of 3 dimensions as (a) Attitude; (b) Interaction; and (c) Problem Solving.

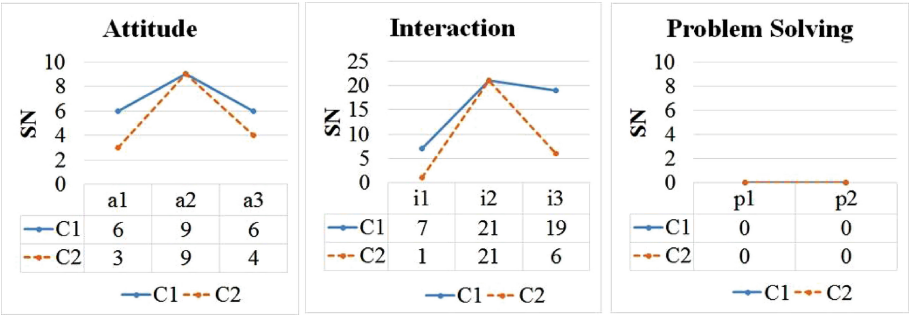

Fig. 4. Ocean Bubbles: its analysis and comparison of 3 dimensions as (a) Attitude; (b) Interaction; and (c) Problem Solving.

First of all, pitch recognition and interval matching required in Rainbow Ladder takes the longest time to develop in pre-operational children. Those children with musical talents or musical background, such as the ability to sense perfect pitch or relative pitch, seemed to progress rapidly, others took more time to practice. The Rainbow Ladder may not be able to give answers for assessment of musical knowledge and abilities. We expected the Rainbow Ladder provided a head start experience and inspiration in perceiving pitch and intervals.

When the game requires practice and repetition, it may challenge children to gain musical knowledge and skills through trying to succeed in gameplay. Bouncing Penguin and Rainbow Ladder provide such challenge, experience, and practice to succeed.

Ocean Bubbles provides children with creative interactions and recorded audio files for listening. Children can improvise as long as they are pleased. They seemed to enjoy tapping the emerging bubbles and listening to recorded improvisation. The analysis and comparison in (c) of Fig. 4—no problem solving—display that a creative music application requires interactions in pre-operational children but with no pre-requisite musical knowledge or skills. Therefore, this game did not involve problem solving skills. Children may only refer to sensory data and intuition knowledge in this gameplay. Providing further experience and learning in music may advance intuition knowledge to the symbolic stage.

Since pre-operational children lack cause-effect logic thinking skills, it limited their problem solving ability but encouraged explorations and inspired enquiries. Compared to our observations of the participants with these analyses and comparisons, children preferred to try out every possible way repeatedly. Few of them tried to ask questions. Influenced by school discipline policy and their personal learning styles, some of them were well behaved, some were energetic, and some always asked questions and gave responses to every move. Based on personal experience and educational training of the researchers, these behaviors are quite normal in pre-operational children.

Figure 3 shows some controversies in the results between the two coders. This application did not always run smoothly. We suspect that problems were caused by the programming bugs or Acer tablet technology deficits. However, children seemed not to be bothered due to the common presence of trial-and-error in a pre-operational child's daily activities.

4 Conclusion

Although many reports says that Adobe Flash is going to slowly fade out in the animation industry, to everyone's surprise, in February 2016 Adobe announced the new Animate CC to continue Flash professional and support HTML 5.0. It not only can be a solution for browser compatibility but also provide a certain amount of demand in job market. In the first part of this research, we developed 8 musical games with ADOBE FLASH and multi-touch technology on the Android system. Based on the purpose of this research, their visual and auditory interface design, testing, and observations of participants, video recordings, and tablet input data records were summarized in the previous publication: "Serious Music Game Design and Testing" [1]. This paper reports the latter

portion with the intention to further the study of the theoretical foundation and its applications, and confirm the credibility and validity through the analyses and comparison of two other coders.

The findings of this qualitative research include: (1) the purposeful aims of game design and multi-touch applications influence children's attitude, interaction, and problem solving; (2) the musical game designed as multi-touch application tends to motivate a pre-operational child's active attitudes and interactions with tablet computers; (3) the musical game that requires practice provides a challenge to pre-operational children; (4) the musical game design with creative functions and recorded audio files encourage interactions and repetition; and require no pre-requisite musical knowledge and skills; Children refer to sensory data and intuitive knowledge in such gameplay, which possesses the potential to expand to a higher level of symbolic knowledge. These findings conclude that these musical applications/games design with multi-touch interactions on Android system not only provide a head start experience in music but also challenge pre-operational children to advance their musical knowledge and skills to a higher level.

Acknowledgments. This research is funded by the Ministry of Science and Technology, ROC in Taiwan.

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