The Pompom: Exploring how tangible and embodied interactions can be integrated within music to contribute to the child development of creative expression

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ABSTRACT
Pompom is an interactive system designed to aid children in musical and visual expression. It combines an on-screen interface and a physical artifact offering children another opportunity to express creativity. The intent was to integrate tangible and embodied interactions within music to explore what role these interactions play for musical and visual expression for children between five and eight. In this paper, it is proven that music can be used as a vehicle for children education, however, the role of tangible and embodied interactions within creative expression for children needs further research.

Author Keywords
Tangible and embodied interaction; Music; Child development; Human computer interaction (HCI); Interaction design.

ACM Classification Keywords
Human computer interaction (HCI); Interaction design; Visualization; Arts and humanities; Education.

INTRODUCTION
Presently, music as a tool is already implemented in early child development. A common example is the "Alphabet song" which is taught by educators and parents to introduce young children to letters. In 2008, Leinonen and Xhemajli (2008) examined children's tendency to replace lyrics with similar sound when first learning nursery rhymes. They concluded that children use music to learn words by mimicking lyrics. In another study conducted by Paquette and Rieg in 2008, when participants were asked how they could learn and remember the words so quickly, one replied: "Easy, put anything to music and I can remember it." (Paquette and Rieg, 2008, p. 229).

Both Paquette and Rieg (2008) and Leinonen and Xhemajli (2008) analyzed how music can contribute to a positive learning environment and found the benefits in fostering creativity through music. According to these authors, musical activities and sharing the joy of creativity can contribute to the development and extension of comprehension skills. Paquette and Rieg (2008) emphasize that music can be naturally integrated throughout all curricular to enhance creativity.

Furthermore, Hallam (2010) supports that integrating music in learning can create permanent neural changes in information processing. Some musical skills, such as the ones associated with the perceptual processing of sound and emotional sensitivity, are more likely to transfer to other academic subjects. Blakemore and Frith (2000) (cited by Hallam 2010) underlines that much learning occurs without conscious awareness proving user's primary focus can be on interacting with music while learning something else.

The intent of this paper is to explore the integration of tangible and embodied interactions within educational tools; this is done by evaluating what role they play in children's creative expression. Xu et al. (2007) (cited by Kountouras and Zannos 2017) defines tangible user interfaces as more explorative, collaborative, and expressive compared to traditional graphical interfaces. Kountouras and Zannos (2017, p. 336) argue that "tangible user interfaces empower artists, boost their creative expression and enhance performing art."

The research conducted in this paper raises the questions if and how tangible and embodied interactions can be integrated into music to become a vehicle for child development in creative expression.

POMPOM
By offering children another opportunity to express creativity through tangible and embodied interactions, the Pompom was designed by taking previously mentioned studies into consideration. Pompom is a tangible and embodied interactive system (see Figure 1) using an on-screen user interface and a physical artifact as an outlet for children's musical and visual expression.

Figure 1. The physical artifact and the latest iteration of the on-screen interface.

On the start screen (see Figure 2), Pompom offers two boards for the user to choose from. Each board showcases a different environmental element with visual animations and sounds. The user is free to explore and press the controller triggering audio and visual feedback on-screen. By doing so, the user creates visual art simultaneously as they play music.

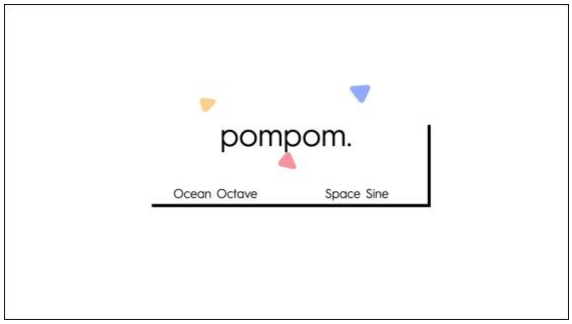

Figure 2. Pompom's start screen where the user can choose from two different boards to play.

According to Hallam (2010), using music as a vehicle is especially effective for eight-year-olds. Tarnowski (1999) explains that music can help children to cope with their feelings as well as expressing themselves. Similarly, Hill-Clark and Robinson (2004) argue and prove that music as a vehicle for literacy learning can help children to keep track of storylines when reading and writing. They describe that involving children in stories by singing a song or playing music related to the story arc help kids understand the literary. When reading a story about a ladybug, the educator decided to combine music with the story to involve the children. A combination of music and a secondary task can help children segue into a deeper comprehension of the subject. As Hill-Clark and Robinson (2004, p.92) put it:

> Involve the children in creating a simple song or melody to accompany the main character(s) of the book. For example: Grouchy, Grouchy Ladybug, Grouchy as can be. When you look, you will see. She's grouchy as can be!

Early Ideation

With prior research in mind, Pompom is targeted to children between five and eight. This led to the development of the persona, Maja (age eight) from the suburbs of Stockholm, who was prevalent throughout the whole design process. Furthermore, by exploring already existing music tools, such as "GarageBand" (Apple, 2017) and the mobile application "Hear" (RJDJ, 2017), it was shown that music can be fun and intriguing when made easy. This inspired the project to move forward with music as the featured topic. Through bodystorming sessions of sequencers and midi boards, it helped highlight the exciting and fun benefits of the interaction.

Physical Controller

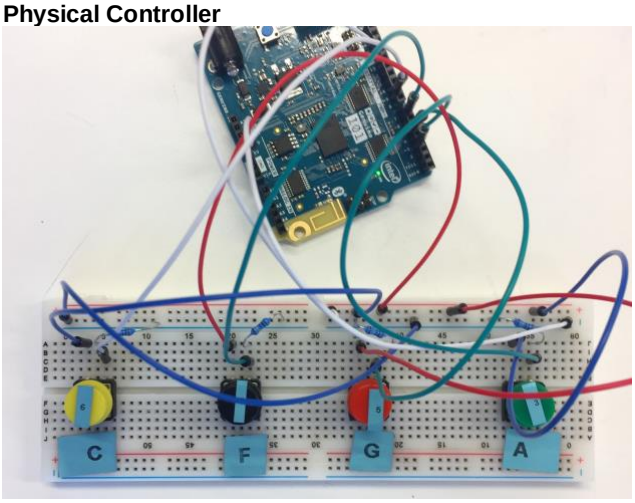

Figure 3. The first iteration of the technical parts in Pompom's physical controller.

The controller includes the Arduino connected to four buttons which communicate with JavaScript (see Figure 3). In our first iteration (see Figure 4), the buttons were made with cotton covered in plastic to mute the harsh clicking sound. It helped with the exploration of the interaction, size, and the feel of the buttons. By using Dreyfuss' chart on Human Factors in Design (Dreyfuss, 1966), this was taken

into consideration when designing the size of the controller to the average size of a child's hand.

With further inspiration from current innovative instrument devices, such as the "Roli Seaboard" (Roli, 2017) with its soft piano-like keys, the design choice was made to have a durable and soft device for the target audience to enjoy without having to be careful when using it. With that in mind, designing an object that strayed away from the traditional instrument design became an important factor. Current classical instruments have its notes or keys in a "row-like" setup. For instance, all string, keyboard, and brass instruments have their keys in rows or columns. Moving forward, it was decided to place the buttons in a triangle shape, making the controller usable from all directions (see Figure 5). The reasoning behind these design choices was to advance from the traditional instrument design and making the Pompom playful and inviting for young children. The triangular shape of the controller and the cushion curves are visual affordances calling for the action of pressing. This invites interactions from any direction, encouraging cooperation between several children.

Figure 4. The first prototype of Pompom's physical controller.

The second iteration of the controller focuses more on the look and feel. It uses foam for the buttons hidden underneath a cover of white fabric and is connected to the computer via USB. By refining the overall aesthetic and built of the controller, the embodied interaction feels more in sync with the on-screen interface when connected to the computer.

Figure 5. The physical artifact: beneath the cushion-like cover there are four hidden buttons and an Arduino. The cable running from the controller connects to a computer.

Creating Audiovisual Art

Each board of the interface has different abstract animations and corresponding sounds (see Figure 6a and 6b). When interacting with the controller, sounds and animations play from and on the computer in real-time allowing the freedom of prolonged tones and tempos with syncing animations. When the user presses quickly or slowly, the animations follow accordingly. The user is free to explore and press on the controller to create their own audiovisual artwork. The animations play in the interface simultaneously as you play and press the controller allowing children to express themselves both musically and visually. When the animations are complete, they reverse, thus playing on an unending loop resulting in every artwork being unique.

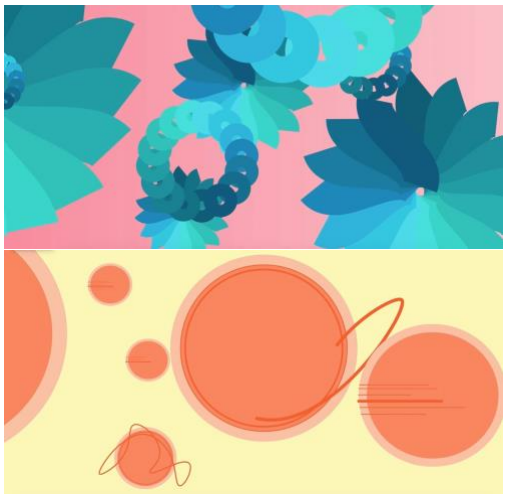

Figure 6a and 6b. Screenshots of the Seashell Sine and the Desert Drum.

Audio

The sound on Seashell Sine is designed and chosen to mimic the frequencies of piano keys. The scale of note A is 440 Hz. The other buttons represent C, F, and G, and their

sound frequencies accordingly. The sounds were developed in HTML5 and fetched from Web Audio API. According to Leinonen and Xhemajli (2008), research showed that classical music with notes like C, F, G, and A is especially easy for children to adapt to. Therefore, it plays frequencies that are in correlation with the piano. This does not apply to the Desert Drum; it only plays like a drum kit for children to learn rhythm.

Since Pompom has two boards, the two types of sounds are made to represent the specific environment of the board. On Seashell Sine, the sounds are made in relation to the ocean and has a xylophonic feel to it. Desert Drum has a drum machine sound to represent the rhythmic feel of the desert's climate.

Figure 7. The participants interacting with Pompom.

USER TESTING

The user testing was conducted with two participants aged five and eight (see Figure 7). During their interaction with Pompom, the participants were interviewed in a semi-structured approach to find out if Pompom's explorative feature is sustainable, which aspects of the visual and aural feedback are the most suited for the target group, and what affect the multiplayer option has for the user experience. The session was observed and documented through notes, photographs, and video recordings.

The children freely explored Pompom using their hands to press the buttons on the physical controller while watching the corresponding animations on the computer screen. The testing session lasted for 23 minutes. The first eight minutes, the participants collaboratively interacted with Pompom using the speakers on the computer alongside the visual representations. After eight minutes, they were asked to try without the visuals and only the audio. The following four minutes, the participants were separated and the oldest participant was asked to use Pompom with headphones. The remaining time they had the freedom to explore and play with Pompom unattended.

Results

The participants stated that they preferred the multiplayer mode over the individual since it is more fun to play music together with someone else rather than playing alone. The participants also preferred wearing headphones as the surroundings were shut out and the interaction then became more intimate.

There were prior assumptions that the Desert Drum would be more fun to interact with because its sounds are similar to a drum machine and it could be used to keep a beat. Through the interviews, it showed that the participants preferred the Seashell Sine board to the Desert Drum proving the prior hypothesis of the user testing wrong. When interacting with the Desert Drum board, the participants only pressed the controller randomly to try out different sounds and requested to go back to Seashell Sine as its sounds and animations were more appealing to them.

Another insight that was gained from the user testing was that the participants found that more boards and more concrete animations would add value to the user experience. They wanted animations that were less abstract and more relatable to the world they know. For example, one participant requested a fish for the Seashell Sine board. When asked what the board would look like if they could draw anything they wanted, one answered "a landscape".

Analysis

As previously mentioned, music can be fun when made easy. Kountouras and Zannos (2017) highlight that children sometimes need guidance and encouragement to develop their own sound production techniques. However, the testing with Pompom showed no demand for such a need. The younger child instantly took initiative in exploring the interaction by randomly pressing the different buttons on the physical board. The older child waited and observed the younger child's interaction before she tried it herself. None of them showed any signs of hesitation about how to interact with Pompom. The observation that the younger child more eagerly interacted with Pompom matches what Kountouras and Zannos (2017) wrote about younger children having a tendency to explore more randomly or uncontrollably compared to older children.

Kountouras and Zannos (2017) made a project that showed that there is an instinctive nature to creating sound textures with hand gestures. The observation that the youngest child instantly intuitively pressed the buttons on Pompom to trigger the sounds and animations strengthens their argument. The shape and the visual appearance of the board might have contributed to this. Furthermore, data collected from the number of button presses evidently showed that the button placed in the center was pressed half the number of times compared to the buttons surrounding it. During the user testing, it became apparent that exploration was needed

for the participants to realize that there was a fourth button placed in the centre of the board.

When interviewing the participants on the visual aspects of the boards, they critiqued on the abstractness of the animations. The participants had a need to physically relate to the boards and suggested landscapes with fishes and oceans instead. This led to the realization that personal biases were involved when designing the animations. Heavily influenced by this, the iterations following the user testing was changed to include environmental elements and relabeled as Ocean Octave and Space Sine (see Figure 8a and 8b).

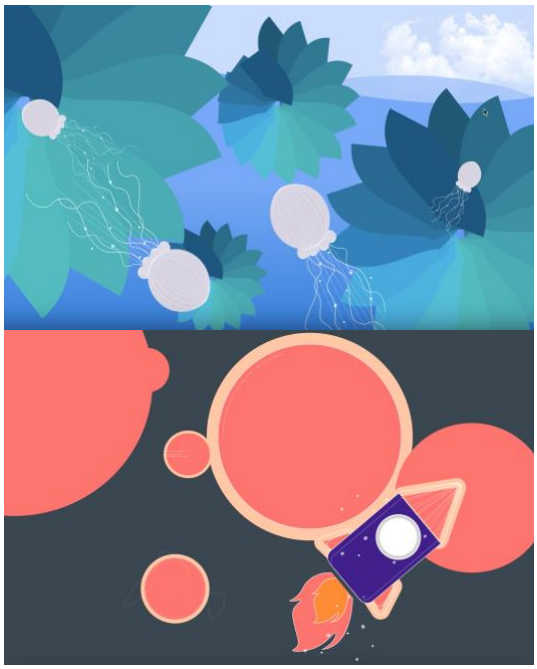

Figure 8a and 8b. Screenshots of the second iteration of the boards resulted in the Ocean Octave and the Space Sine.

DISCUSSION

As the children preferred multiplayer over single player, though headphones over speakers, it was shown that a key aspect of this concept is to be able to show user's work to others and to be able to play together. However, when used alone, the number of presses on the buttons in total increased. This raises the question if the Pompom should be used independently with headphones or collaboratively. Another important factor to take into consideration is the sustainability of the exploration. One way to keep the interaction with Pompom interesting for a longer period of time might be to add features that allow the users to share and design their own animations and sounds. User-created and shareable boards would broaden the spectrum of boards available and might increase the sustainability of exploration.

The user motivation and concentration is of importance, especially when making devices for children. (Leinonen and Xhemajli, 2008). The research shows that adding aspects such as beats and rhythm might make the children unmotivated since it could offer a more difficult device for the children to understand. In contrast to a classical instrument, one of the key features of the Pompom is that the user is unable to play an incoherent sequence or out of key when using it. This is to provide the younger children with a device that is about having fun while learning how to express themselves visually and musically. Possibly, the effect of Pompom's inability for failure can lead to children losing their interest or concentration for further engagement. Pompom might lack the aspect of motivating children to keep expressing themselves creatively since there is no room for skill-development regarding the interaction itself. However, skill-development regarding creative expression is still an apparent driving factor.

There was also discussion on adding an aspect of gameplay to increase motivation, however contrary to that, Kountouras and Zannos (2017) found that experimentation, collaboration, and fun are increased when limitations and restrictions of gameplay are removed. Accordingly, instead of gameplay, Pompom can perhaps include a second layer interaction where users could benefit from being able to make different artworks and animations depending on how and when certain buttons are pressed. Like Street Fighter (Capcom, 1987) combos, perhaps a specific order can trigger a special on-screen experience.

CONCLUSION

The Pompom offers a way for children to express themselves musically and visually without the use of normative musical instruments and traditional art tools. With predetermined animations and sounds, it invites children to practice music and art without first developing the skill sets from taking piano lessons or sketching classes.

Pompom's embodied interaction creates a new opportunity for child development in creative expression. For Pompom to have a more sustainable interaction, implementing a second layer interaction could be of value. Perhaps by maximizing the use of one board through the interaction combinations may result in different audio and visual feedback. Therefore, further research on how children will or will not understand second layer interactions is needed.

There may be value in investigating the tension found in the user testing concerning the fun aspect of collaborative creative expression and being able to experience the intimate interaction of using headphones while alone. There is also potential in prolonging the explorative aspect of the Pompom by letting users share and create new boards and animations with each other.

Prior research has suggested the need for a set of tools aiming at transforming the current status quo in the field of educational tools into a more embodied form. Pompom has merely opened up the discussion on child creative expression, further design iterations and research are

required when using tangible and embodied interactions in child development.

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