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Body Food: Touch Mat for Emotional and Physical Development of Children

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Abstract

This study proposed 'Body Food,' an interactive tactile mat that provides interactive visual responses and induces physical activity in young children at the time of developing tactile and five senses, along with the touch of various stimuli. The product combines fiber materials and digital content to achieve a variety of visual and auditory responses in real time when children touch the fabric. User tests were conducted for 4-year-olds and the result was positive in terms of physical exercise and artistic experience, but quantitative testing is required to generalize it. In the future, we will complement physical and digital contents to realize more complete product.

Keywords: Children, Wearable Device, Gamification, Sensory Development, Smart Toy

1. Introduction

Early childhood is a foundational period for the development of a human being throughout his or her entire life. Since experiences during this period have a complex impact on emotions and the physical body, it is important for guardians to allow children to have various experiences. The "Nuri Curriculum for Ages 3-5," announced by the Ministry of Education is divided into five areas: physical exercise, communication, social relations, art experience, and natural exploration, as part of providing quality education to young children. [1] However, the age group for smartphone users is getting lower and the increasing rate of dependent behavior on cell phones [2] makes it hard to keep young children away from smartphones. The lack of a diverse tactile environment and the over-invasive habit of staying in one place and watching media are also real concerns among mothers, as it affects children's physical development. [3]

While there is a growing concern about the use of media by young children, studies show that effective learning can be achieved through media if conditions such as repetitive viewing, utilization of famous characters, and content appropriate for the child's stage of development are met. The design of appropriate content can have a positive impact on early childhood development. [4]

This period is a time when the concept of objects is still being formed in young children. It is also the time when stimulation for the development of five senses is important for intuitive thinking as children rely on perceptual characteristics such as size, shape, and color of things.[5] Tactile sense is the first nervous system to develop immediately after birth and works effectively when vision and hearing begin to develop.[6] When a young child physically manipulates the interface elements of digital content, he or she experiences sensory interactions through sensory organs as the interface changes.[7] This develops the coordination ability of the

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child's eyes and hands, and helps with various forms and size responses, development of one-to-one responses, and the formation of partial-whole relationships.[8] In this study, interactive tactile mats that can utilize these characteristics are proposed to help in both the development of the five senses and the body of young children.

2. Related Works

2.1 The Effects of Children's Sensory Development Products

Since sensory development in children is an important period, various studies about the effectiveness of sensory activities are being conducted, and early childhood-related products distributed on the market are also common. In particular, it has been observed that activities involving the five senses have a positive impact on a child's creativity, character, etc. According to Lee Kyung-yeon(2017), the early childhood art education program which uses materials that can be felt by the five senses has positive effects on a child's creativity, playfulness, and art expression.[9] Also, according to a study by Jin Da-jeong(2018), the case of barefoot play corresponding to physical activity establishes subjectivity to the body as well as muscle development.[10] This suggests that sensory play and physical activity not only influence growth but have an impact on children in all aspects. Sensory development products, especially tactile products, are divided into three areas, as shown in Table1. These products utilized materials that are safe for young children and allow children to be able to recognize them through touch. These are also combined with characters, sound, story, etc. to engage a child's interest.

Table 1. Product type for infant's sensory development

| Type | Details of product | Example |
|-----------|---|---|
| Doll | It is a toy designed as an animal, fruit, or character. Each part of the doll consists of various colors and materials. Some products can make a sound in analog ways when children shake or press them in a hand-held size. |  |
| Storybook | Various textured materials are inserted into a storybook. Since the tactile play moves forward along with the narrative structure of a the storybook, an educational effect can be expected. A child may lose interest in play if a guardian does not read the book or participate in the play. |  |
| Mat | It is a product that allows children to feel a variety of different textures on a mat. By using the whole body while playing, it stimulates children to make dynamic body movements and helps their physical development. |  |

2.2 Digital Interactive Contents for Young Children

Digital interactive content is not just a type of communication that conveys digital content, but is a play-type and participatory-type interactive content that allows users to experience contents in a realistic way according to their actions. [11] Digital interactive content is being produced for a variety of purposes, but for content intended for young children, it is being studied in such a way that it would catch the interest of children and increase educational effectiveness. According to a study by Lee Kwang-hyung (2008), automatic recognition technology of "RFID" is incorporated into animal stuffed toys so that children can naturally enjoy learning languages, nursery rhymes and English by playing with them.[12] In addition, Won Hye-min's research (2011) has developed a sensory game that enhances muscle endurance, agility, and flexibility by combining the technology of copper recognition and speech recognition with skipping rope. [13] In the study

of Jeong Ji-eun (2015), AR technology was introduced on word cards so that children could learn words by immersion, and so that those who are teaching could easily manage contents.[14] What these studies commonly emphasize is the link between the content's substance and technology that young children may find interesting. In this process, the aspect of the interface of whether a child can easily manipulate the content through the use of technology, and the educational aspect of whether this content can help the development of a child at the time of growth was considered. In addition, teaching methods and digital content guidance are observed to be factors that enhance the effectiveness of interactive digital content in young children.

There are various disagreements about the effectiveness of digital content in young children. In the past, the focus was on the negative perception that the use of digital content in young children could lead to addiction or deterioration of creativity.[15] However recent studies on educational perspectives of video media and their impact on the development of creativity in children showed that young children have high interest in, high level of utilization, and positive performance of video media.[16] This suggests that, with research and technological development, interfaces that can continuously positively affect children are being studied, and the use of appropriate media content is likely to have a positive impact on young children.

3. Interactive Tactile Mat, Body Food

3.1 System Design

'Body Food' is an interactive tactile mat, which allows children to engage in stretching activities as well as tactile play, aiding their emotional and physical development. Unlike traditional tactile-related products, the product combines fiber materials and digital content to achieve a variety of visual and auditory responses in real time when children touch the fabric. This induces synesthetic development from the tactile sense to the other senses.

3.1.2 Application Technology

During the prototype development phase, conductive threads were used to turn physical contact with various tactile fiber materials into digital signals. Conductive thread means fibers with relatively low electrical resistance use conductor materials such as metal semiconductors, carbon black and metallic oxide.[17] Conductive threads can carry current in the same way as wires, so they are evaluated as practical materials suitable for making circuits in fiber-based projects. Also, it is safe for children to touch and play with. In this study, a stainless-steel conductive thread with a resistance of 280 ohms per foot was used.

As shown in Fig. 1 and Fig. 2, the Body Food consists of a mat(E) that connects the tactile patch group(A) and the start patch(B), a PC box(C) that houses the Arduino and the drive laptop, and a monitor(D) that shows audiovisual contents. Since the human body is also a conductor, when the body touches the conductive thread connecting the tactile patches (A), (B) and the mat(E), the resistance of the mat changes.

The variation in the capacitance is then transmitted through a conductive thread to the Arduino inside the PC box(C), and interpreted from the PC and output audio-visual content from the monitor(D). Through this process, children are encouraged to participate happily in tactile and stretching activities by checking the sounds and animations of various fruits that responded in real time according to physical activity on a monitor.

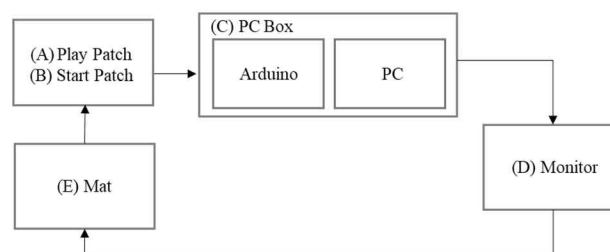


Figure 1. Operation Flow

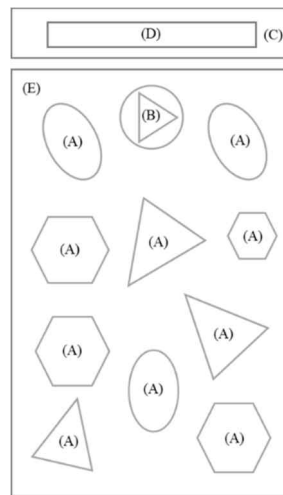


Figure 2. Layout of the prototype

3.2 Mat Design

Young children exhibit intuitive thinking that rely on perceptual characteristics such as size, shape, and color of objects.[18] Therefore, the mat was designed as the first prototype using fruit stickers, taking into account the factors of 'shape' and 'color' to induce the intuitive thinking of young children. The first prototype was tested internally, and it was pointed out that there was a lack of sensory factors to interest the child. Reflecting this, the final design was developed around three design elements: "shapes," "colors" and "materials," taking into account the element of "materials" to induce sensory development through touch.



Figure 3. First Prototype



Figure 4. Final Product

3.2.1 Design Factors Reflecting the Perceptual Characteristics of Young Children: Shape and Color







Children develop a sense of stability, comfort, curiosity, and friendliness when they express basic shapes such as curves, oblique lines, straight lines, circles, and triangles in an observable color or apply colors that suggest specific shapes.[19]

Therefore, as shown in Table 2, the mat was patched with fruits that are familiar to young children and easy to simplify in basic shapes. In addition, the patch color was chosen as a color that was highly observable and reminiscent of each fruit. In particular, the most commonly used indexes in young children characters were yellow, red, green, and white.[20]

3.2.2 Design Elements to Induce Sensory Development through Touch: 'Material'

Each patch used a variety of materials, such as leather, sequin, silk, fur, and lace, to help children experience the sensation of touch that is reminiscent of the fruit.

Table 2. Mat design components with 'fruit' motif

| 'Shape' and 'Color' Elements | 'Material' Element | Circular image | Final production image |
|--|---|--|---|
| <ul style="list-style-type: none"> -The oval fruit body gives you a sense of stability. - The oblique lines arranged in zigzags elicit curiosity. - Visibility is enhanced through color. | <ul style="list-style-type: none"> - Expresses the tough outer shell of a pineapple as a leather material. - Diversifies tactile feel with hard sequin material |  |  |
| <ul style="list-style-type: none"> - Simplifies form to the basic shape of a triangle - Intuitively uses colors reminiscent of watermelons - Red and green contrast increases visibility | <ul style="list-style-type: none"> - Uses a crisp and cool silk reminiscent of watermelon, a summer fruit - Expresses the hard seeds of watermelons with beads |  |  |
| <ul style="list-style-type: none"> - Simplifies form to a circular basic shape - Intuitively uses orange-like colors | <ul style="list-style-type: none"> - Expresses the fluffy inner bark of oranges using artificial puffs. - Diversifies tactile feel with hard sequin material |  |  |

3.3 Contents Plan

In BodyFood, content is played in two phases. Children can enjoy tactile play on the first phase and stretching play on the second.

'Tactile play' is a game where young children focus on the sensation felt at the end of their hand by touching various patches on the *body food* mat, while 'stretching' is an exercise game that lengthens the whole body by touching a number of different patches simultaneously.

Touching the patches attached to the mat allows children to interact with digital content.

To enable the child to adjust to the mat, the two contents can be continuously experienced at the touch of the start patch as shown in Figure 3.

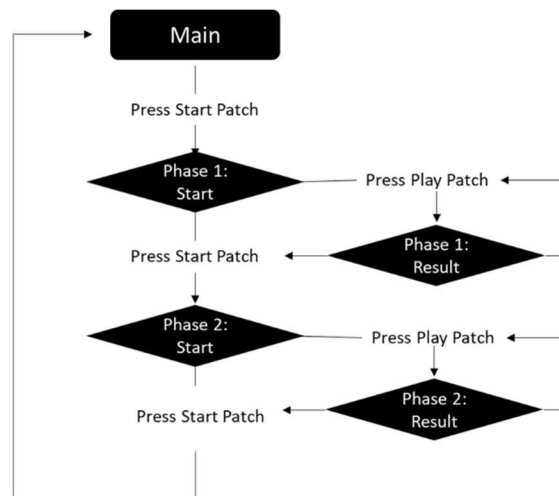


Figure 5. BodyFood content Flow

3.3.1. Phase 1: Tactile Play

Phase 1 is a game that focuses on touch done by feeling the material of each patch of fruit. First, when children press Start Patch in the middle of the mat, the tactile play begins with the message 'Let's feel the texture of the fruit.' Children feel the texture of pineapples, watermelons, and orange patches attached to the mat. At this point, it switches to a screen (Result) that tells them which fruit it is, along with the sound associated with each fruit. The sounds of chewing, tapping and peeling of fruits were used to visualize the sensation of touch with the sense of hearing.

3.3.2. Phase 2: Stretching Play

Stretching play is an extension of tactile play, which allows the whole body to act actively. While playing tactile play, press the 'Start Patch' button again to begin stretching with the message 'Find the Same Fruit.' When a child finds and clicks on the same fruit patch on the mat, a children's song and animation content appear on the monitor. With an animated screen showing fruits popping up like firecrackers, children are encouraged to be more interested.

Table 3. Body Food interaction design

| State | Start | Physical Interaction | Result |
|----------------------|----------------------------------|----------------------|--------------------------------|
| Main | Enjoy fruits with your body] | | Feel the texture of fruits |
| Phase1: Tactile play | Feel the texture of fruits | | Pineapple |



Touch each fruit patch

Phase2:
Stretching
play



Find the same fruits



Touch the same shape
of fruit patches on the
mat simultaneously



Well done !

3.3.3 Mapping and Communicating with Guardians

Body Food has a simple interaction and UI, both Phase1 and Phase2 play, so that young children can basically play on their own. However, while playing with *Body Food*, guidelines were made so that one or two guardians could talk and guide the children so that they could concentrate on emotional communication and physical activities. It was based on the content of the Ministry of Education, Science and Technology's Nuri Curriculum for Ages 3 to 5. [21]

First of all, in the case of Phase1 tactile play, young children participate in tactile play and naturally become interested in basic art elements such as fruit shape and touch, and are guided to become interested in artistic elements. Children start to recognize the fruit they are touching, and compare the differences in the feel of each fruit while determining its shape. On the site, guardians are required to collect information about the objects that the child is touching, things being compared with other fruit patches, shapes and colors being recognized, and guide the child to touch various fruits.

In Phase 2, various movements are done to perform physical activities, as well as cooperative activities with guardians. It is performed not only with one action, but also by utilizing both hands and both feet. The guardians are also asked to participate in play and share emotional communication with the child by making physical contact with the child[22] In the process of searching for the same fruits, children naturally develop cognitive skills so they can extend their hands, and lift their legs to ensure active physical activities.

Table 4. Instructions for guardians

| State | Education goal | Example |
|--------------------------------|--|---|
| Phase1: Tactile play | 1) Become interested in the color, shape, and texture of nature and things | "I want you to feel the texture of a fruit. What kind of fruit do you like OO?" "What color is this fruit?" "How do you think this fruit is different from that fruit?" "What kind of texture does the |

| | | |
|--------------------------------------|---|--|
| | | fruit here have? Will you touch it?" |
| Phase2: Stretching play | 1) Try to balance the body in different positions and movements | "What fruit do you think is the same?" "In what motion can I press these fruits?" |
| | 2) Try to control the movement of each part of the body | "Would you like to press it in a different motion?" |
| | 3) Exchange help with others; cooperate with each other. | "I'm going to press this, and OO will press this?" |



Figure 6. Participation in Body Food play

3.5.1. User Experience Evaluation

The purpose of this study is to develop and explore the effectiveness of an interactive tactile mat 'Body Food' that helps children develop their senses and physical development. For this purpose, the government wanted to conduct user assessment for as many children as possible, but due to difficulties in detecting children that conform to the observation conditions and environment, a qualitative experiment with two children was conducted instead.

The subjects enjoyed various kinds of toys and had no difficulty playing with strangers as a four-year-old boy and girl. On December 26, 2018 and January 24, 2019, a four-year-old girl and boy played 'Body Food' with the help of their respective guardians for a total of two hours on both days. On the next hour, the children's guardians were interviewed on the usability of the mat.

3.5.2. User Evaluation Tool

The assessment of '*Body Food*', an interactive tactile mat, was prepared based on 'Nuri Curriculum for Ages 3-5,' which was commissioned by the Ministry of Education, Science and Technology and the Ministry of Health and Welfare.[23] The Nuri curriculum is presented by age considering the level of development of young children and is divided into five areas: physical exercise, health, communication, social relations, art experience and natural exploration. In this study, in-depth interviews were conducted with guardians who participated in the play to see if the content of "body exercise and health" and "art experience" areas related to the emotional development and physical development of young children meet the educational goals of 4-year-olds.

3.5.3. Conducting the Experiment

In addition to children and guardians, three researchers helped in conducting the experiment. Before starting play, the three researchers explained how to use '*Body Food*' and guided them how to teach it to the child. The child's guardian participated in play with the child, helping the child understand the rules of play and then in-depth interviews were conducted based on their observations. The play process was recorded as a video, and the interview was recorded and reviewed by the three researchers.

3.5.4. Experimental Results and Discussion

Table 5. In-depth interview results after using body food

| Area | Details | Objectives and Questions by Area | Answer (girl's guardian) | Answer (boy's guardian) |
|------------------------------|--|---|---|--|
| Physical exercise ·Health | Increasing and utilizing sensory abilities | Are multiple sensory organs utilized? | "Audience, sight, touch... I liked using various senses. My child, especially, likes to sing a song, so it is easy to sing along with her and it's fun, so she's more absorbed in auditory elements than in other parts." | "My child gets easily fed up with the simple response of other toys, but with Body Food, he seems to have actively participated in it without getting tired or being bored by the sound of Body Food and "animation." |
| | | Is physical balance maintained in various postures and movements? | "** (child name) still lacks the strength to maintain a movement for a long time in a stretching game looking for the same fruit. But she liked the point where she used her whole body to try various movements." | "He needed some help with stretching because the mat was a little bigger than his body. In general, however, it was easy to maintain balance and enjoy playing." |
| | Regulating the body | Can you control your muscles through eye and hand coordination? | "The fruit on the mat is colorful and tactile, so she wants to keep touching it. I think the tangerine has a particularly good texture of fluffy fur, and she grabbed it by hand, rubbed it, ripped it off... I think she did a good job of using her muscles." | "Even if I didn't explain the rules, he could understand the game by watching the animation on the screen. He is interested in the fruit from the monitor, and I think the experience of touching and seeing it is well done." |
| | Basic Exercise | Can you move your body in various ways? | "At first, she didn't understand the rules of play, so she was | "My kid liked a little bit of dyn |

| | | | |
|-------------------|-----------------------------|--|--|
| | s while standing? | just in front of the monitor, and gradually she understood the game and actively played looking for the same fruit. It allows her to stretch her arms and legs or to bend her back. She moved in various ways." | amic activity, running and rolling, rather than staying in one position on the usual air mat. I think it would be better if the contents vary so that he can move more variously." |
| Experience of Art | Exploring musical elements | Are you interested in various sounds, music dynamics, tempo, rhythm, etc.? "My child was very interested in the song that appeared at the beginning of the play. She was so absorbed that she couldn't play the game while listening with concentration. She even imitated the song." | "The sounds of play vary not only from songs, but also from effects such as chewing and tapping fruits. My child was interested in the sound and was curious about what sound it is." |
| | Exploring Artistic Elements | Are you interested in the color, shape, and texture of nature and things? "The fruit was colorful and pretty, so my child became interested the first time she saw it. She especially like the color that sparkles these days, so she liked pineapple the most." | "Because the shape of the fruits are intuitive, he could see what the fruit was like at a glance. It is like looking at the shape of the fruit and reminiscing about the taste of the fruit. We can play in various ways, asking questions about color, shape, and texture." |

First of all, the girl showed a greater immersion in auditory elements than the visual and tactile elements. On the other hand, the boy showed immediate interest in the color and material of the mat rather than in the auditory element and focused on a variety of touch sensation. In the stretching game looking for the same fruit, the girl found it difficult at first because she did not understand the rules of the game well. Also, she could not keep her movements in balance for a long time because of a lack of muscle strength. However, with the help of her guardian, she was able to gradually understand the rules of the game and actively participated in it. In the case of the boy, the mat was larger than his body, so the guardian's help was required during the stretching play. Nevertheless, he quickly understood the rules of the game and participated in the play according to the animation on the monitor. He also preferred dynamic movements such as running and rolling, rather than stretching and maintaining a balanced posture on the mat, and liked to participate in the play with several people together. In addition to stretching, the boy's guardian also suggested contents where several children can enjoy various games together on the mat.

4. Conclusion

This study proposed 'Body Food,' an interactive tactile mat that provides interactive visual responses and induces physical activity in young children at the time of developing tactile and five senses, along with the touch of various stimuli. Materials with conductive threads and tactile elements are produced in the final design in conjunction with digital content and tested for actual 4-year-olds. Observation and in-depth interviews showed that young children showed a response that could be linked to educational aspects, including physical exercise and artistic experience. This suggests a positive direction of image media for children. However, it is deemed that the responses and actions of the participants were important and an in-depth interview with a small group of subjects was conducted. Therefore, the limitation of this study is that it is difficult to demonstrate the effectiveness of the product quantitatively.

This research is expected to develop the product into a smart toy that will enable children to actively participate in physical activities based on various contents in the future. For this purpose, a process wherein there is interaction with digital content should be developed and implemented on a more complete product,

considering the aspects of digital content such as 1) characterization, storytelling, game elements, etc., 2) modularization of products, and product development according to the size of the child's body.

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