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Application of Somatosensory Computer Game for Nutrition Education in Preschool Children

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Abstract: With the popularization of technological products, people's everyday lives are now full of 3C (computer, communication, and consumer electronics) products. Children have gradually become acquainted with these new technological products. In recent years, more somatosensory games have been introduced along with the development of new media puzzle games for children. Several studies have shown that somatosensory games can improve physical, brain, and sensory integrated development in children, as well as promoting parent–child and peer interactions and enhancing children's attention and cooperation in play. The purpose of this study is to assess the effect of integrating somatosensory computer games into early childhood nutrition education. The subjects of this study were 15 preschool children (aged 5–6 years old) from a preschool in Taichung City, Taiwan. We used the somatosensory game "Arno's Fruit and Vegetable Journey" as an intervention tool for early childhood nutrition education. The somatosensory game production uses the Scratch software combined with Rabboni sensors. The somatosensory game education intervention was carried out for one hour a week over two consecutive weeks. We used questionnaires and nutrition knowledge learning sheets to evaluate the early childhood nutrition knowledge and learning status and satisfaction degree in the first and second weeks of this study. The results showed that there were no statistically significant differences between the preschool children's game scores and times, as well as nutritional knowledge scores, before and after the intervention. Most of the preschool children highly enjoyed the somatosensory game educational activities. We reveal some problems in the teaching activities of somatosensory games, which can provide a reference for future research on designing and producing somatosensory games for preschool children and somatosensory game-based education.

Keywords: somatosensory computer games; nutrition education; preschool children

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Citation: Chang, I.-C.; Yen, C.-E. Application of Somatosensory Computer Game for Nutrition Education in Preschool Children. *Computers* **2023**, *12*, 20. https://doi.org/10.3390/computers12010020

Academic Editors: Teen-Hang Meen, Charles Tijus, Cheng-Chien Kuo, Kuei-Shu Hsu, Kuo-Kuang Fan and Jih-Fu Tu

Received: 14 December 2022
Revised: 12 January 2023
Accepted: 13 January 2023
Published: 16 January 2023

1. Introduction

Younger generations are now extensive users of digital devices, with children aged 8–10 spending an average of 65 min a day playing video games [1]. Play is a powerful learning method through which students can develop new skills and engage in new social roles; furthermore, playing games can meet their enduring psychological needs [2,3]. In the classroom, teachers can use games to foster learning motivation and participation in students, as the process of playing the game is very engaging and not a painful learning process [4].

Serious games are defined as games whose primary goal is to educate rather than entertain, which can be used to combine novel interfaces (e.g., wearable sensors) with teaching methods for educational purposes [5]. Depending on the target audience, these serious games focus on improving areas such as diet, exercise, hygiene, and social skills [6]. Serious games can be used as innovative tools in classroom teaching and have caught the attention of educators as they offer new and more powerful ways of teaching in schools and new ways for students to learn in the modern information age [4]. Serious games employ media-rich, role-playing, and story-based content to teach, train, and change the knowledge, attitudes, and behaviors of players. Serious games have the dual purpose of being entertaining while promoting behavioral change [1].

Motion Sensing Games are a new type of serious game which use the body movements of the player to operate the game. In the game, the player can use the motion of their hands or feet to control the characters or objects in the game. Somatosensory technology allows users to directly use body movements to interact with surrounding devices or environments without using complex control devices, allowing players to interact more deeply with game situations [7–9].

In 2006, Nintendo of Japan launched the Wii Remote (or Wiimote). In March 2010, Sony released the PlayStation Move somatosensory game device, and somatosensory games became a highlight of the game industry at that time. In 2012, Microsoft released the Kinect sensor device, which uses a gesture-operated interface to stand out among somatosensory game devices, and it became the mainstream of the somatosensory game industry. Kinect possesses a powerful bone-tracking function, which is able to track 6 complete bones and 25 joints and can perform accurate posture evaluation. Every action or posture made by the player can be recognized by the device, and the accuracy of actions can be automatically analyzed to give corresponding feedback [4,8].

In recent years, somatosensory games have been widely used in education for children with special educational needs, sensory integration training, medical rehabilitation, parent–child interaction, physical enhancement, sports training, social interaction, speech therapy, elderly rehabilitation, and other fields. Chang et al. [10] used the Tetris game as a reference to develop an interactive somatosensory game for the elderly with mild cognitive impairment. The study has evaluated the subjective feeling of somatosensory games integrated into rehabilitation through intuitive gesture control interactive games. The results showed that somatosensory games made the elderly feel interested and increased their willingness to continue rehabilitation. Using Kinect as a somatosensory game interaction tool, previous research [11] has mainly explored how intelligent somatosensory interactive activities could restore hand movement function to children with autism, and the impact of somatosensory games on autism rehabilitation training. The studies have shown that somatosensory games had positive effects on rehabilitation training for children with autism. Consequently, 92.9% of the people thought that the training process could meet the comfort requirements and 89.3% of the people thought that the training aids could bring a positive experience to the training of children with autism. Xu et al. [12] took 187 intellectually disabled children as research objects and randomly assigned them to experimental and control groups. The experimental group was provided with Kinect somatosensory games for 8 weeks. The study showed that somatosensory games could help to improve the children's intelligence, daily living skills, physical ability, body flexibility, and language communication ability. The study of Lu et al. [13] took 300 school-age children with autism randomly assigned to control and experimental groups. They found that somatosensory games can significantly reduce the severity of impulsive behavior in school-age children with autism and improved their self-confidence, cognitive function, and living skills. The study of Kandroudi et al. [4] has utilized 40 serious games as educational tools for children with autism, and the results indicated that computer games improved their communication skills, social behavior, imagination, expression of feelings, and social interactions with other children with autism.

Jean Piaget has proposed that the sensorimotor system is an important part of cognitive development [14]. At this stage, young children understand the world by coordinating their sensory experience with body muscle movements. When a child's motor and mental ability develops to a certain extent, along with the development of sensory movement, play behavior will occur. Through this behavior, they may feel happy. A child's physical development is rapid and characterized by high energy in the early childhood stage. During this stage, children enjoy physical activities, they can communicate well with their peers, and they like challenging and competitive games. Children tend to learn by looking at pictures. Somatosensory games allow children to fully interact with the game through the game screen, characters, and the interactive process. Somatosensory games have fun and challenging characteristics, which can promote motor development and learning in children [8]. More and more parents pay attention to early childhood education. However, there are often some problems, such as learning difficulties, lack of learning motivation, and concentration on the process of young children's daily education. Somatosensory system is an emerging interactive video game and multimedia technology. The funny, interesting, controllable, and interactive nature of the somatosensory games can enhance learners' interest in learning and internal motivation. Moreover, learners can continue to try when facing difficulties and challenges, which lets them gradually obtain a sense of achievement. Therefore, embedding the learning process in the somatosensory games would be a solution for happy learning [15,16].

The integration of somatosensory technology and education mainly relies on games. Somatosensory games can be used as new tools for teachers to innovate educational approaches. However, games cannot teach anything by themselves and teachers need to find a creative way to integrate the virtual world of games into learning activities. For example, through designing an appropriate game to integrate educational goals for children, such as simple operations, quizzes, overcoming a challenge, a simulation experience, fun, and so on [8]. For children, healthy lifestyle behaviors include healthy eating and physical activity. Children need to have correct nutritional knowledge and healthy dietary habits, increase the intake of healthy foods, reduce the intake of unhealthy foods, and do moderate to vigorous exercise every day [17]. In recent years, taking advantage of the fact that most children enjoy playing games, serious games have been increasingly used to encourage healthy lifestyles in children and as an innovative method to support health education and treatment. Combined with educational and psychological resources and techniques, serious games integrate elements of engagement and fun to achieve health outcomes [18]. At present, preschool teachers rarely integrate computer games into teaching activities in preschools. We aimed to understand the feasibility and effect of somatosensory game education combined with nutrition education activities. The purpose of this study was to examine the effect of somatosensory games integrated into nutrition education in the early childhood context.

2. Methodology

This is a pilot study to evaluate the effectiveness of integrating somatosensory computer games into nutrition education for preschool children. The research tools and procedures are as follows.

2.1. Study Subjects and Research Tools

The study subjects were preschool children aged 5–6 years from a private preschool in Taichung City, Taiwan. The private preschool is a medium-sized institution, which has 8 classes in the preschool, 15–20 preschool children in each class, and a total of 120 preschool children. Children are assigned to classes according to their ages. Compared with toddlers, children aged 5–6 years are more mature in physical and mental development, and they are more able to understand operating instructions. Therefore, we recruited one class of children aged 5–6 years to participate in this study. A total of 15 preschool children (6 boys and 9 girls) participated in this study.

The research tools are as follows:

1. Questionnaire: We collected demographic information about the children, including age, gender, and so on.
2. Nutrition knowledge learning sheet: The nutrition knowledge learning sheet was designed by the researchers. The question type is the matching question. The question content of the nutrition knowledge learning sheet involved recognizing six categories

of foods (whole grains; vegetables; fruits; legumes, fish, eggs, meat and their products; oils, fats, nuts and seeds; dairy products). The question content of the learning sheet includes the kiwi fruit, egg, cabbage, vegetable oil, cheese, rice, pork, pineapple, carrots, milk, etc. These foods all appear on the game screen. Preschool children have to identify which food group each food shown on the screen belongs to in a question. A complete test contains a total of 10 questions, 10 points each per question, and a full score of 100 points. We invited three scholars and experts in the field of early childhood education to review and revise the content of the learning sheet to establish the appropriateness and validity of the content of the nutrition knowledge learning sheet.

3. Somatosensory game record sheet: The researchers recorded the scores of preschool children playing the somatosensory games on the record sheet.
4. Degree of preference for somatosensory game: We used a Likert scale to understand the children's preference for somatosensory games. The score ranges from 1 to 5 points. The higher the score, the higher the preference, and vice versa.
5. Somatosensory game: In this study, the somatosensory game production involved the Scratch software combined with Rabboni sensors. As shown in Figure 1, the Rabboni sensor has a built-in six-axis gravity sensor (IMU, Inertial Measurement Unit), BLE Bluetooth transmission, and computing components that can transmit sensing readings in real-time. These sensors provide a variety of options regarding sampling frequency and dynamic range and are equipped with LED lights to indicate the operating status of Rabboni and its power display. The Rabboni sensor facilitates Android sensing signal acquisition with various programming educational applications, including Scratch, Python, Unity, Java, and App Inventor. Rabboni sensors were specially developed for AIoT (Artificial Intelligence of Things) programming education, app development, AI smart sensor interconnection, or motion detection-related research regarding various intelligent applications. In summary, the Rabboni AIoT Program Education Device possesses a gravity-sensing function and a complete programming language integration interface, such that a designed educational program can be synchronized with AI, IoT, and sensor learning.

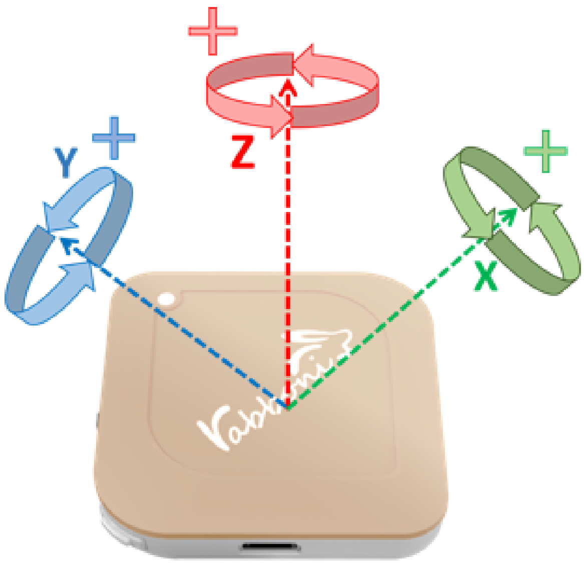

Figure 1. Rabboni sensor.

2.2. Somatosensory Computer Game

2.2.1. Design Background

The somatosensory game of this study uses the Scratch software combined with the Rabboni sensor. All game functions were designed and programmed by the researchers.

The game background was drawn using SketchBook painting software. This somatosensory game was used as an auxiliary tool to teach nutrition education for preschool children.

The educational goal of the somatosensory game design was to teach preschool children about healthy and junk food, through which children can learn correct nutrition knowledge and dietary habits through a fun and interesting experience. The name of the somatosensory game is "Arno's Fruit and Vegetable Journey", and the background of the game is that a dinosaur (Arno) wishes to have a healthy body. Thus, he decides to start looking for healthy vegetables and fruits to ingest them.

The game background has three screens, including an amusement park, sea world, and forest (in sequence). During the game play, a lot of vegetables, fruits, and junk food fall from the top of the computer screen. The protagonist, Arno, must avoid eating unhealthy junk food and choose to eat healthy fruits and vegetables. The level of game score is calculated according to the nutritional value of the vegetables and fruits. The nutritional value scores, from high to low, are 5 points, 4 points, 3 points, 2 points, and 1 point, respectively. Once the game is successfully completed, the game score is displayed. When the protagonist intakes more healthy food, the game score will be higher; if he ingests junk food, the number of heart symbols (life points) will be reduced by one on the game screen. When all three hearts (i.e., 3 life points) are deducted, the player fails the game.

2.2.2. Interface Design and Operations

The figure below shows the design and configuration of the computer game Scratch interface. The start screen of the game shows the protagonist Arno the dinosaur; see Figure 2. The "Rules" button is clicked to display the scoring instructions. When the "Start" button is clicked, the game starts. In the background of the game, there are three levels (i.e., amusement park, sea world, and forest) in sequence, as shown in Figures 3–5. Players can change the acceleration (acc X and acc Y) by using the Rabboni sensor device worn on their hands, in order to control the dinosaur Arno to move left and right to eat vegetables and fruits through tilting the sensor to the left or right. If the Rabboni sensor is tilted down, the dinosaur Arno will jump. When the three levels are completed, the game will display the "Great" successful screen, and the score will be displayed on the upper left of the screen; see Figure 6. If the player eats junk food three times, the three heart symbols (life points) on the game screen will disappear and they will fail the game. The "Game Over" screen appears to finish the game.

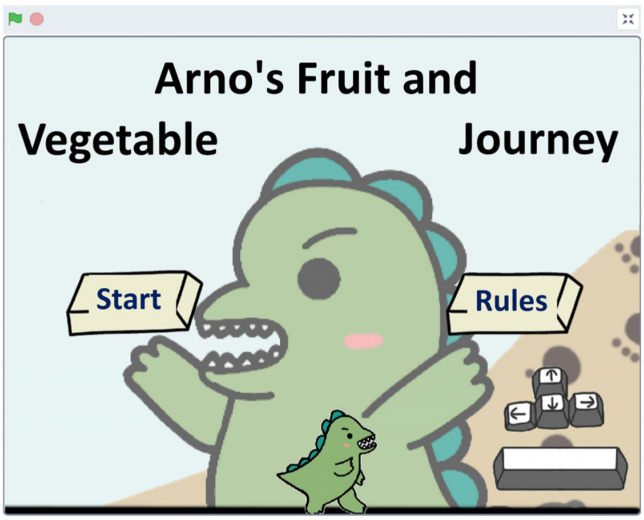

Figure 2. Game start screen.

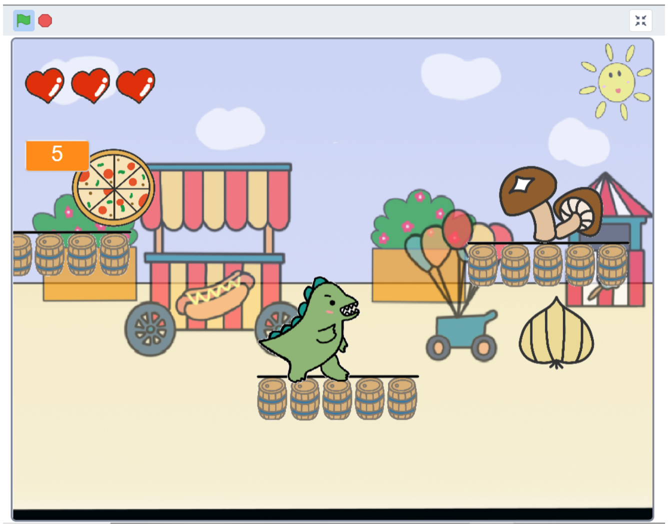

Figure 3. Amusement park background.

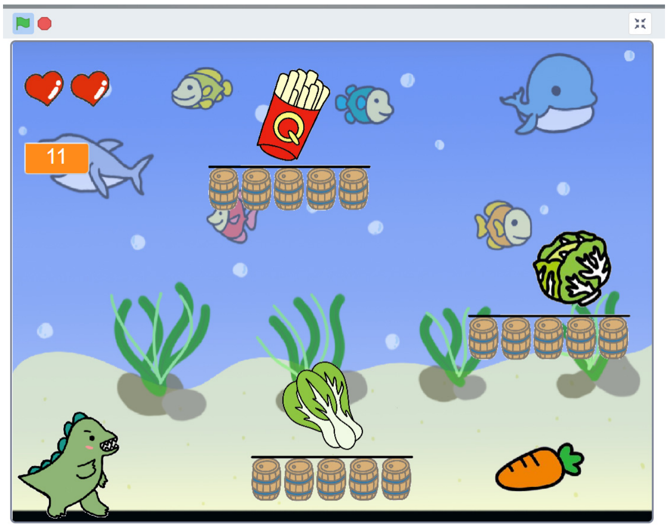

Figure 4. Sea world background.

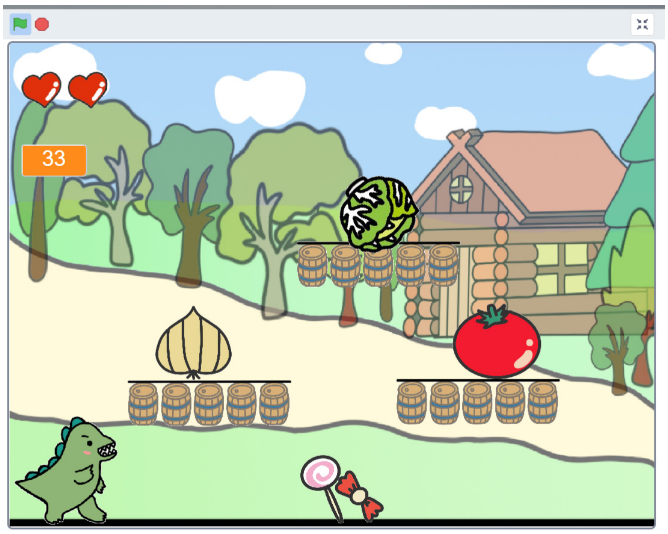

Figure 5. Forest background.

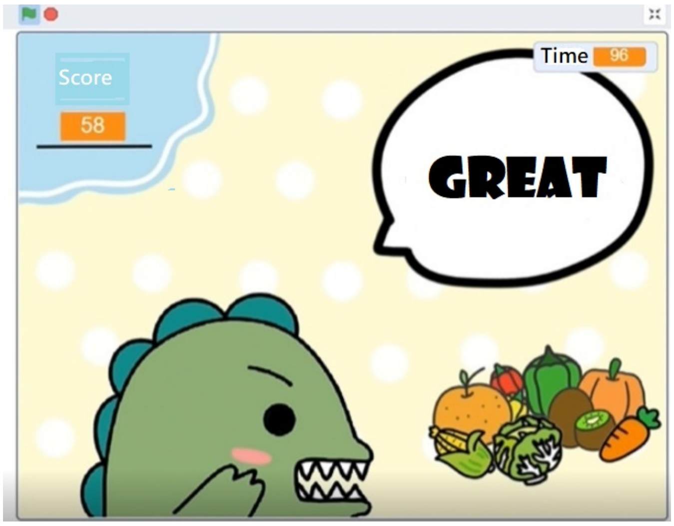

Figure 6. Game success screen.

2.2.3. Study Processes

A total of 15 preschool children aged 5–6 years old were recruited for our study. These preschool children were from a private preschool in the central region of Taiwan. The participants received the somatosensory game education intervention for 1 h once a week over two consecutive weeks. The content of the somatosensory game education included motivation, development activities, and integration activities. We used the self-made electronic picture book "Arno's Fruit and Vegetable Journey" to induce learning motivation in preschool children, and the children played the somatosensory game in groups (3–4 children per group). Finally, we allowed children to share their play experiences through group discussions.

The demographic information of the participants was collected, and we used the nutrition knowledge learning sheet to evaluate the children's nutrition knowledge before the first week of the somatosensory game education intervention. After the second week of the somatosensory game intervention, we used a nutrition knowledge learning sheet to evaluate the children's nutrition knowledge again, as well as filling out the questionnaire to understand the children's preference for somatosensory games.

2.3. Statistical Analysis

Data were analyzed using the SPSS software package (version 20.0; SPSS for windows, Inc., Chicago, IL, Chicago). The demographic characteristics used descriptive statistics. A paired sample *t*-test was conducted to compare the differences in nutritional knowledge scores and game scores before and after the intervention.

3. Results

There were 15 children aged from 5–6 years old (6 boys and 9 girls) in this study, as detailed in Table 1.

Table 1. Descriptive characteristics of subjects.

Variable	Item	Number (n = 15)
Age	5 years	9
	6 years	6
Gender	Male	6
	Female	9

Table 2 shows the scores obtained in the somatosensory computer game. The post-test game scores of preschool children were lower than the pre-test scores, but there were no statistically significant differences. The post-test game time was higher than that in the pre-test but, again, there was no significant difference.

Table 2. Scores and time of somatosensory computer game.

Variable	Pre-Test	Post-Test	p-Value
Somatosensory game scores	63.80 ± 7.00 #	61.93 ± 9.74	0.29
Somatosensory game time (seconds)	147.40 ± 39.30	165.40 ± 90.97	0.52

Values are mean ± SD.

There were no statistically significant differences in the nutritional knowledge scores of the preschool children between the pre- and post-test scores, as shown in Table 3.

Table 3. Nutritional knowledge scores of the preschool children.

Variable	Pre-Test	Post-Test	p-Value
Nutrition knowledge score	98.60 ± 1.92 #	97.20 ± 6.66	0.44

Values are mean ± SD.

Most of the preschool children (60%) liked very much, and 7% liked, the somatosensory game. However, three children (20%) disliked the somatosensory game very much, The average score for liking the somatosensory game is 3.8, as detailed in Table 4.

Table 4. Degree of liking the somatosensory game in preschool children.

Item	Number	Percentage
Like very much	9	60
Like	1	7
Ordinary	2	13
Dislike	0	0
Dislike very much	3	20

4. Discussion

The results of this study indicated that there were no statistically significant differences in the scores and time for the somatosensory game between pre- and post-test results. There were also no statistically significant differences in nutritional knowledge scores pre- and post-test. This was the first time that the children had tried to learn using a somatosensory game, and they were relatively unfamiliar with the somatosensory game. The sensor to control the movement of the game character requires fine movements and sensitivity to accurately operate the somatosensory game. However, motor development has not yet been completed in preschool children. Therefore, the preschool children were prone to frustration and lower achievement when playing the game. This may be the reason why the results showed that the post-test game scores were lower than those of the pre-test, and the post-test game time was longer than the pre-test. However, these results presented no significant differences. Moreover, it should be noted that there were three children who disliked the game very much.

The length of the somatosensory games course intervention was only two weeks in this study. Most children were not familiar with somatosensory games and, as a result, they often failed the game due to mistakes made during sensor operation. This may be the reason why there was no significant difference between game score and learning performance, and a small number of the children were not satisfied with the somatosensory game. If the children could operate the sensor smoothly, the score of the game would be higher and their achievement and satisfaction may be higher in the game. In early childhood, physical development has not yet fully matured and children need more time to operate and learn new technological tools. This study is the first attempt to integrate somatosensory games into early childhood nutrition education. The number of subjects was small and the intervention time was short, which was a limitation of this study. In future research, longer somatosensory game course intervention times will be required for young children to learn.

For this aspect of somatosensory game design, programming of the sensor needs to consider the development and maturity of children's limbs, and it must be designed accordingly to be simple and easy to operate. In this study, the action required to move the game character left or right was to rotate the sensor left or right, respectively, and that meant that the participants often needed to turn their hand left and right. However, they often failed in this action due to over-rotation of the sensor, as they did not know whether the sensor had received a signal. It is difficult for preschool children to perform internal and external rotation with a sensor worn on their hand. If somatosensory game design can incorporate tactile sensation feedback, the child can understand when the sensor has received the signal and no longer needs to turn. In addition, the somatosensory game design can use the operation of the hands, feet, or waist to increase the fun and varied experience of the game. Young children are not yet matured in their concept of left–right orientation. It is best for children to use the mirror operation method when operating a somatosensory game, so that they can better identify the direction of their limbs and reduce operational mistakes. In addition, the design of somatosensory game should not be too long, in terms of game time. It should be simple to operate, interesting, and conform to the principles of physical development of preschool children [8].

It is in children's nature to like to play games. They can exercise their bodies, inspire their intelligence, and interact with the outside world through games. Somatosensory games are a new type of computer game involving physical activity, which breaks through the mode of traditional keyboard games. Somatosensory games can promote the development of gross motor skills, body control, and hand–eye coordination in children. Somatosensory games include interactive, situational, and participation characteristics, and can have a great effect on the development of motor skills in children with special needs. In addition, somatosensory games can promote the psychological development of children, which is conducive to the cultivation of children's body awareness [19].

With the development of somatosensory technology, it has been integrated into all fields of life, including exhibitions, emerging experience locations, school multimedia teaching, and children's education [8]. The sensorimotor stage is among the first stages of cognitive development. During this period, preschool children develop an understanding of the world through coordinating their sensory experiences and motor actions, making it a critical period to promote children's sensory integration ability [11]. At present, with the rapid development of serious games, somatosensory games, as a type of educational tool, can be used to assist physical rehabilitation in children. Somatosensory games are expected to become an excellent way to promote children's physical development [19]. In the future in the early childhood education field, somatosensory games will provide new applications and changes in early childhood education and learning methods. However, it is necessary to pay attention to the correctness of how children wear the sensors and to adjust their posture appropriately when playing somatosensory games, as the direction of the sensor light must be in front of computer so that the computer can sense the movement of the sensor.

Reviewing the previous studies on the application of serious game education in students, the objects of most research [9,12,13,17–19] are children over 8 years old. This study explored the effectiveness and feasibility of integrating somatosensory games into teaching activities for preschool children aged 5–6 years old. In the process of the research, we found that the somatosensory game course can really fascinate preschool children. When the class time was over, several children started to get angry or cry to express that they did not want to end the course but to continue playing the game. It proves that this somatosensory game education is very attractive to preschool children and can arouse children's interest in learning. Therefore, somatosensory game education could be applied to children with special educational needs, such as attention deficit hyperactivity disorder, to help children learn happily in the future.

5. Conclusions and Future Work

This study is a pilot study considering a somatosensory game for early childhood nutrition education. The results indicated some problems in somatosensory game education, which may serve as a reference for future researchers to conduct research on somatosensory game education and improve somatosensory game design. A somatosensory game is played through changes in the player's body movements, thus closely aligning the game with body movement. Somatosensory games provide broad prospects in early childhood education while giving preschool children more opportunities to use multi-sensory models to learn more happily in games.

In future research, it should be ensured that the design of somatosensory games is simple, sensitive, and interesting and meets physical activity needs in accordance with the physical development of preschool children. Future studies should increase the time of the somatosensory game intervention so that children can spend more time familiarizing themselves with the new technological game equipment and enhance their sense of achievement when playing games. In addition, somatosensory games can be designed as two-player games in order to increase the opportunities for children to interact with each other.

Author Contributions: I.-C.C. and C.-E.Y. conceived of the idea, designed and performed the experiments, analyzed the results, drafted the initial manuscript and revised the final manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This study have not received external funding.

Informed Consent Statement: The informed consent was obtained from participated preschool and child and their parents or guardians.

Conflicts of Interest: The authors declare no conflict of interest.

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