Effects of 3d Printing Interactive Technology on Special Education for Children with Different Disabilities

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The Asian Conference on Education 2018
Official Conference Proceedings

Abstract
Using assistive technology as a tool in special education is an important intervention for children with special need in recent studies. This study proposes to develop an interactive tool that functions as a low-cost, learning interface for children with different disabilities. Two children from resource class in elementary school participated in this research. This research applies 3D printing technology to develop a multi-media interactive feedback interface to train children with learning or physical disabilities to insert coins and improve learning motivation. Microsoft Visual C# is used for the human-machine interface. By means of inserting coins, users are able to increase the number of points won or vision and audio interface feedback. After the task is judged, the real-time feedback is processed by a prerecorded key wizard script as the entire control video process. The multi-media content design as teaching materials to increase learning opportunities By means of this interactive technology and Microsoft Visual C# Windows program, participants were able to use the "coin insertion" tool instead of the left key of a PC mouse. The purpose can be achieved on the basis of the interactive content adjusted for individual needs. This research investigate the effectiveness of a fine motor skills training process for the upper limbs of students with physical disabilities. It involves the parents and teachers in obtaining real feedback. The conclusions of this study are also discussed. This study also applies low-cost technology in home-based interactive learning method for children with different disabilities.

Keywords: 3d Printing, Interactive Technology, Special Education

Introduction

Use of effective assistive technology can help provide special education of decent quality for children with special needs. As a result of the rapid progress in technology, integration of computers in education has become a worldwide tendency. Through interaction with computers, individualized teaching can be achieved to enhance the motivation of students to learn by practicing repeatedly and to increase their concentration(Lin, 1995). With instant feedback and no limitation of labor and time, computerized interactive technology can provide concrete, practical and interesting learning for students with special needs and train them to develop different skills. For this reason, this type of technology has become popular among teachers of special education. However, great differences exist between students with special needs. The teaching materials and instruments required have to be specifically designed and produced according to such differences. Hence, good tools are rather important for teachers of special education. As far as software is concerned, if such teachers can use the Internet properly, they can find the right resources to reduce the time needed to produce teaching materials. They may also apply word-processing software, briefing software and film-editing software to conduct image processing and create multimedia with light and sound effects to stimulate the learning motivation and interest of students (Mayer, 2009). As for hardware, since many students with special needs have trouble using interactive devices because of their poor physical coordination, appropriate modifications or adjustments are needed to assure students can enjoy the fun of interactive technology during the learning process. Nonetheless, a lot of the push switches, wobble switches and trackball switches available on the market are expensive and many families cannot afford them.

To overcome the problems of high costs and individual differences, this team has adopted 3D printing techniques and developed a coin insertion system. It is equipped with various coin insertion inlets (for regular coins, marbles, ping pong balls, etc.) and connected to a mouse and toys for children with special needs to undergo insertion training to interact with the computer and take courses and physical movement training through game playing. Thus, they will be able to practice continuously without losing interest.

Microsoft Visual C# is applied in this study to complete the software design to allow users to operate coin insertion to score. After the mission is accomplished, prerecorded Quick Macro is applied for script processing. Children with special needs have to use coin insertion tools to control the playing of the entire film and the film contents or courses can be adjusted according to the needs of individual students.

There are three participants in this study. The first one is a child with severe cerebral palsy and the second one with moderate cerebral palsy. Due to muscle tension, their upper limbs do not function well and they have difficulty holding things. Plus, articulation problems also exist and they have trouble communicating with others. Therefore, this study is intended to use the coin insertion system produced with 3D printing techniques to train their fine motor skills and also to increase their learning motivation and effects through their interaction with computers. The last participant is a child with severe autism and unable to talk. His main problems include barriers to social interaction, impaired verbal communication and repetitive stereotyped behavior. It is hoped that this study can increase the opportunity for him to learn to interact with

the outside world by practicing with the coin insertion system and watching the films.

Method

In recent years, 3D printing techniques have been applied extensively in different fields. Continuous improvements and advances in 3D printing techniques have opened a new door in development of assistive technology for special education. Through experiences of touching objected produced with 3D printing, students' imagination can become reality. In this study, 3D printing techniques were applied to design and construct 3D models and print out the products. In order to meet the needs of different students, models had to be constructed, printed and modified repeatedly before the final products are completed. The process of 3D printing is (1) Use drawings or scanning software to create digital files of objects; (2) Transform digital files into digital slices to separate objects into layers of data; (3) Store data on SD cards and transmit them to be read by the 3D printer; (4) The 3D printer injects out materials in layers that stack up to form 3D objects，as shown in Fig. 1.

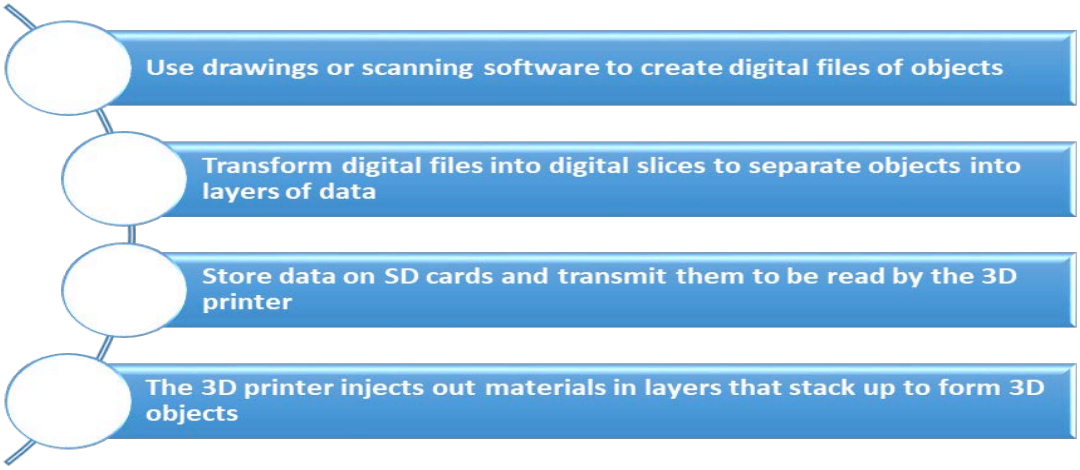

Fig. 1 3D Printing Process

Commonly applied 3D modeling software includes 2D drawing software (Microsoft Paint, Paint Net, PhotoCap, Adobe Photoshop and Inkscape) and 3D drawing software (Blender, 123D Design, Sketch Up, TinkerCAD and Sculptris). In this study, TinkerCAD was adopted to build the models. Common plastic, nylon, paraffin, food ingredients, paper, cement, metal and ceramic powders can all be used as the "inks" of 3D printers. Polylactic acid (PLA) made by combining corn starch and sugar cane derivatives was adopted in this study because it was biodegradable and would not release any toxic substance when printing was carried out at around 190□ (Guo, Zhang, Huang, & Huang, 2017).

The coin insertion system produced with 3D printing had to be tested and adjusted to accommodate a number of types of training for various functions which required insertion holes of different sizes. After repeated adjustment and trial use, several coin insertion systems of different calibers were developed in this study, as shown in Fig. 2.

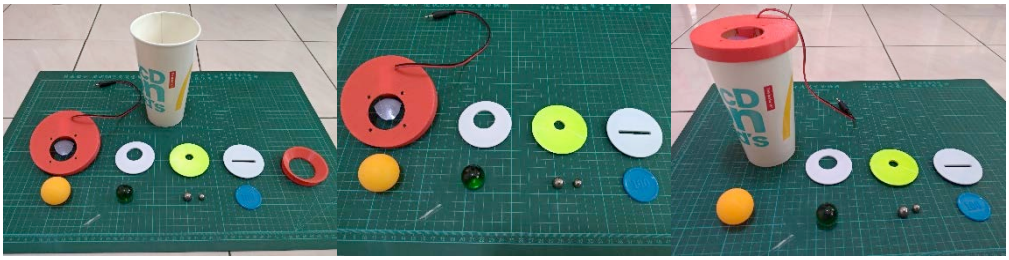

Fig. 2 Coin Insertion Devices of Different Calibers

Hardware was also needed. The models printed out had to be connected to micro switches, audio lines, and modified mouse devices to form an interactive system with the computer and toys, as shown in Fig. 3 (3dp Bubble machine designer: Chen Wei-Zen).

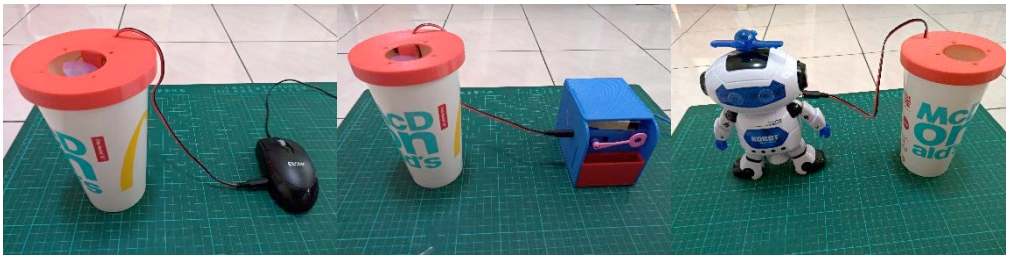

Fig. 3 Models Connected to the Mouse, Bubble Machine and Robot to Form an Interactive System

To achieve interactive effects, contents of Chinese textbooks were adopted to produce simple PPT files which were played to teach students vocabulary and word building and train them to understand meanings of words. In addition, Microsoft Visual C# was applied to develop a film control system to increase the interaction and concentration of autistic children and allow them to wake up Quick Macro for script processing in order to control the process of the films which were selected from Youtube according to the needs of individual students.

Case Study

Assistive technology provides the opportunity for students with special needs to participate in different activities. It can also enhance their learning motivation for them to undergo function training. The posture, muscle training, senses and cognition are all important factors that have influence on the development of fine motor skills. For children with poor physical coordination or concentration, we can design simple games to train their fine motor skills. The coin insertion system developed in this study for training purposes uses relatively cheaper 3D printing tools and micro switches to allow interaction with computers and toys. In other words, the children can simply move the ping pong ball or coin from the palm to the fingers and insert it in the coin insertion system and the interactive system (such as the computer, bubble machine or toys) will increase the strength of the children and stimulate their motivation for and interest in training. This exactly is the game-based learning emphasized. Children can continue to practice without losing interest. We have confidence that practice makes perfect. Repeated practice is bound to produce learning results and assure students will achieve the learning targets.

The case study method was adopted in this study to examine the effects of students with special needs when they used the coin insertion system produced with 3D printing and interactive devices. The three participants in the study included one male fourth-grade student with severe cerebral palsy, one female fifth-grade student with moderate cerebral palsy and one fifth-grade female student with severe autism.

The motor development of cerebral palsy patients can be divided into spastic, athetoid and mixed types. Such patients have problems expressing themselves verbally or in writing and their learning can be affected by their cognitive impairment(Zeng, 2009；Scherzer & Tscharnuter, 1990). Rehabilitation is usually difficult but necessary. To prevent muscle degeneration, they need to undergo rehabilitation repeatedly to enhance their muscle strength. For this reason, we hoped to provide them with a simple tool to help them with their training and learning.

Due to poor cross-area processing functions in the brain, autistic children cannot connect related information or experiences together. As a result, their development of speech ability and language comprehension is affected. The most effective way to help the language comprehension of autistic children is to link language and actual scenarios together(Luo, 2013). We hoped to use the coin insertion system to train the fifth grader with severe autism to improve his language comprehension as well as provide him with the opportunity to interact with the environment.

Case 1 child with severe cerebral palsy
In the future, he would be able to use what he learned in everyday life. The child with severe cerebral palsy, case 1, as shown in Fig. 4, suffered serious muscle contracture because of muscle tension, but the results of study showed that use of the coin insertion system and interactive games could improve his static tripod grasp ability and movement of each finger. Dexterity of fingers and appropriate grip strength were required for him to adjust the angle and strength according to the material, smoothness, size and shape of the object to hold and move the object. When applying the coin insertion system to train, he could only use ping pong balls. At first, the more he tried to insert the balls, the stronger his muscle tension became. However, after interactive games were adopted, his insertion movement and tension control improved significantly.

Fig. 4 Case 1

Case 2 child with moderate cerebral palsy
The female fifth grader with moderate cerebral palsy, case 2, as shown in Fig. 5, was right-handed and her right hand was better developed and able to grab larger objects, such as a communication pen, but she needed training to learn to operate the thumb-index web space and finger tips. After assessment, her special education class teacher suggested to enhance her right hand finger movement and train her to practice how to apply the correct strength to grab objects according to their sizes and shapes.

The teacher also believed her left hand also had to be trained to increase the coordination of both hands, so she could use both hands together. Therefore, the coin insertion system and interaction with the slides were applied to improve the functions of her both hands while courses were also integrated to train her linguistic and cognitive abilities.

Fig. 5 Case 2

During training, she kept requesting not to turn on the speakers because she didn't like music. The films from Youtube didn't have much appeal to her. However, she found the vocabulary teaching material specifically designed for her acceptable. She was able to use her right hand to complete a series of training smoothly. When inserting coins, she held the paper cup and put the coin inside easily. With marbles that were smaller in size, she had problems. Her left hand could put in ping pong balls but had trouble with coins. The tension in her left hand was strong and the McDonald's cup was too tall; therefore, it was not easy for her to put in coins. At one point, she tried to stand up to do it. Later, the cup was made shorter to give the proper height for her to put in coins. When interacting with the bubble machine, she got very excited when seeing and touching the bubbles.

Case 3 child with severe autism

Case 3 is the female fourth grader with severe autism, as shown in Fig. 6. When learning, she often could not have eye contact with others and it was difficult to see her facial expressions. Her socializing and communicating capacities lacked integration and she had no speech ability. She could get overly concentrated on something, some interest, conduct or action, or simply lack concentration. The teacher hoped the coin insertion system and the film featuring children's songs could improve her ability to interact with the environment.

Fig. 6 Case 3

The main design for her was the coin insertion system and interaction with the film of children's songs. She had to insert coins to play the film which stopped automatically after about ten seconds and she had to put in more coins to activate the film again. It was hoped the training could increase her concentration and her ability to follow instructions. At the beginning, there was no reaction and her eyes did not focus. The

coin insertion accuracy was low and the teacher had to lend a hand and give instructions repeatedly. After many tries, the teacher no longer needed to give assistance and only provided cues verbally. Accuracy increased, her eyes became more focused and she showed considerable interest in learning.

When the training ended, the teachers and parents of the three children were interviewed. They all expressed the training system was beneficial to the children's concentration and able to improve their learning interest and motivation. The teachers also hoped further use of systematic methods could be adopted to train the children.

Conclusion

Besides increasing the stability of fine motor skills, the coin insertion training can also be applied in daily life, such as using piggy banks, vending machines, coin-operated washers, capsule toy machines, etc. (Meng, & Jane, 2016；Waters, 2013). However, coin insertion is more difficult for some children with special needs. Different injuries may cause children with cerebral palsy to have other impediments, including visual impediment, aural impediment, speech impediment, low IQ, behavioral impediment and learning impediment, etc. They need a lot of assistance and rehabilitation to develop further and learn. Unfortunately, they often lack motivation. However, the coin insertion system produced with 3D printing and the interaction design can boost their motivation to undergo rehabilitation. The equipment required is cheap, easy to carry and not difficult to acquire. For itinerant teachers, special education teachers and parents, the burden will be lighter. Moreover, it is easy to make and to use. Plus, different teaching materials and interactive devices can be combined to give students more opportunities to practice without getting bored. Hence, this system can be promoted and applied in special education. Meanwhile, since computers are equipped with simple touch-control and audio-video interfaces and all kinds of application programs can be used to provide learning through visual, aural and touch approaches, they can provide positive assistive functions for autistic children to learn to interact in society, to express themselves verbally, to correct negative behavior and to develop special talents.

The coin insertion system used in this study is produced with 3D printing techniques. Different coin slots are connected to toys or devices to activate the mouse to allow children with different needs to undergo coin insertion training and achieve the purpose of controlling the toys or the computer. At the same time, the coin insertion movement is also a type of rehabilitation. After students with special needs are trained to use the interactive coin insertion system, their hand-eye coordination and language comprehension become better while their short attention span and lack of motivation and patience can also improve. Because of the opportunity to learn independently, students' learning interest and motivation increase. In addition, during the post-training interview, the parents and teachers gave positive responses, indicating the interactive system can trigger the learning motivation and interest of students. Therefore, it is worth promoting.

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