A 3D Printed Chinese Character Learning Art Educational Tool for the Blind and Visually Impaired

Xiaotong Zhang, College of Design and Innovation–Tongji University, China
Jingwen Tian, College of Design and Innovation–Tongji University, China
Tanhao Gao, College of Design and Innovation–Tongji University, China
Hongtao Zhou, College of Design and Innovation–Tongji University, China

The Asian Conference on Education 2022
Official Conference Proceedings

Abstract
As one of the world's five most widely spoken languages, Chinese is also the most widely spoken language globally. The Chinese language consists of a writing system and a pronunciation system, with Chinese characters being the most critical language component. As Braille is a two-dimensional static image, it is difficult for the visually impaired, especially the non-sensitive blind, to learn by touch, presenting an unimaginable barrier in the teaching curriculum and posing a challenge to the Chinese language curriculum taught by teachers. In order to improve this dilemma, designing an educational tool suitable for visually impaired people to learn Chinese characters can solve the difficulties in the actual teaching of Chinese in special education schools in China, improve the barriers to learning Chinese for visually impaired people, and assist in moving the teaching curriculum towards a relaxed, happy and welcoming environment. The production of a Chinese character interface combined with 3D printing technology enables a literacy interface that is simple to design, quick to shape, durable, has a wide choice of printing materials and is more inclusive. 3D printing technology makes it easier to move from two-dimensional static images to three-dimensional images, making it easier to learn to read Chinese characters and experience the joy of touching Chinese characters for reading. This study hopes to popularise art education for the visually impaired in China, it provides a replicable design education research model for the education of people with disabilities in China and globally.

Keywords: Blind and Visually Impaired, Art Education, 3D Printing, Chinese

1. Introduction

As one of the world's five most widely spoken languages, Chinese is also the most widely spoken language globally. The Chinese language consists of a writing system and a pronunciation system, with Chinese characters being the most critical language component. The structure of Chinese characters is more complex and contains profound philosophical ideas. Their origins are in pictorial drawings used to remember events, so Chinese characters mainly express the movements of script forms and the truths and allusions contained in the characters. Chinese Braille was first developed from the phonetic formulation of the Kangxi Dictionary, which is quite different from the internationally used Braille, so learning Chinese characters is the foundation of Braille learning. As Braille is a two-dimensional static image, it is difficult for the visually impaired, especially the non-sensitive blind, to learn by touch, presenting an unimaginable barrier in the teaching curriculum and posing a challenge to the Chinese language curriculum taught by teachers. In order to improve this dilemma, designing an educational tool suitable for visually impaired people to learn Chinese characters can solve the difficulties in the actual teaching of Chinese in Chinese special education schools in China, improve the barriers to learning Chinese for visually impaired people, and assist in moving the teaching curriculum towards a relaxed, happy and welcoming environment. The production of a Chinese character interface combined with 3D printing technology enables a literacy interface that is simple to design, quick to shape, durable, has a wide choice of printing materials and is more inclusive. 3D printing technology makes it easier to move from two-dimensional static images to three-dimensional images, making it easier to learn to read Chinese characters and experience the joy of touching Chinese characters for reading.

The research plan is to develop a three-stage Chinese character literacy interface tool for visually impaired people in three stages: point, line and surface. In the first stage, a Chinese character sequence using the ancient classical Chinese Confucian work *Surnames* as the interface composition will be used as a learning tool for visually impaired persons to learn their Chinese family names. The pictographs are accompanied by corresponding Braille explanations to aid the learning of bump characters while the visually impaired learn the pictographs. In the second stage, the Chinese tool dictionary *Ci Hai* is used as the blueprint for the interface composition, and words are used instead of characters to form word groups. In the third stage, It is mainly used in Taoist culture, and in the early days, it was borrowed for Taoist symbolic seal engraving, representing the epistemology of Taoist thought of the unity of heaven and man, the unity of matter and self, and the oneness of mind and matter, representing the combination of wisdom in ancient Chinese philosophical thought, and signifying good blessings in traditional Chinese folk culture. It is fun and educational. This study hopes to popularize art education for the visually impaired in China, enhance the learning of traditional Chinese culture and increase the cultural literacy of the disabled. It provides a replicable design research model for the education of people with disabilities in China and globally.

2. Difficulties faced by blind and visually impaired people in accessing arts education

2.1 Current status of education for blind and visually impaired people in China

Tactile is the most common cognitive modality used by blind and visually impaired to familiarize themselves with objects, understand information, and perceive their surroundings (Collins, J. J., Imhoff, T. T., & Grigg, P. 1996). Due to the absence of visual perception, the main channel for acquiring information is lost. At the same time, tactile and auditory senses

become the primary sensory organs for acquiring information, reading Braille requires touching and recognizing words with fingertips, walking requires feeling the texture of the blind path with the feet, and holding a guide stick to detect whether there is an obstacle ahead. The tactile muscle memory is the primary sensory organ for reading Braille and recognizing words, walking with the feet, and holding a cane to see an obstacle ahead. Through touch, blind people can recognize the form and material of objects and obtain richer information in terms of texture (Lu,L. 2020). However, there is some difficulty in recognizing the complete form of an object. In addition to perceiving objects and space through touch, blind people can also judge the size of space and the direction and speed of object movement through hearing (Roman, L. G. 2009). Hearing is an essential perceptual channel for blind people to absorb and learn information from the outside world. After processing auditory information to judge the surrounding environment and assist in complementing their other senses, the characteristics of sound, such as timbre, volume, and pitch, will also enhance the impressions of blind people.

2.2 Lack of art education tools for blind and visually impaired people

It is difficult for blind people to learn abstract vocabulary, and traditional teaching methods for blind people are based on linguistic scenario descriptions. However, since Chinese Braille is defined according to syllables, which is slightly different from the standard international Braille, there are challenges in learning Chinese characters. Therefore, designing a Braille language and writing cognitive products based on Chinese characters is necessary and feasible. The designed auxiliary writing cognitive product should be different from the previous learning tools with only Braille touch bumps (Zhang, X., Tian, J., Gao, T., Zhang, D., & Zhou, H. 2022). This product is essential for assisting blind people in learning Chinese characters and popularizing general education for the visually impaired to enhance their literacy level and feel the beauty of words (Figure 1).

Because Braille is a two-dimensional static image, it is difficult for people with visual disabilities, especially blind people without photoreceptors, to learn by touch. Unimaginable obstacles exist in the teaching curriculum and present challenges to the Chinese language courses taught by teachers. In order to improve this dilemma, designing an educational tool suitable for visually impaired people to learn Chinese characters can solve the difficulties in actual Chinese teaching in Chinese special education schools in China, improve the barriers to learning Chinese for visually impaired people, and assist in moving the teaching curriculum toward a relaxed, happy, and welcoming environment. The 3D printing technology will make it easier to learn Chinese characters from two-dimensional static images to three-dimensional images and to experience the joy of reading Chinese characters by touching them.

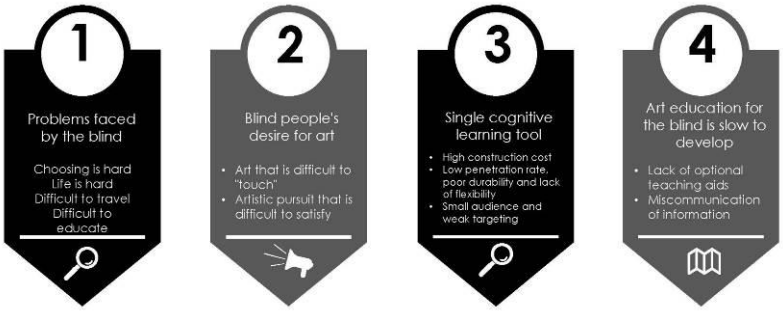

Figure 1: Difficulties faced by blind and visually impaired people in accessing arts education

3. Principles of art design adapted to blind and visually impaired people

The material, weight, temperature and shape, specification and texture of the objects touched, together with the voice-assisted explanation and environmental ambience, can assist the blind person to the maximum extent in gathering information and gaining an in-depth understanding of the art exhibits.

Choose exhibits at the forefront of art and safety. The blind and visually impaired lack the visual senses to judge the type of object, weight and distance. When selecting and designing exhibits, protecting the rights of special people to have unique cognitive modalities and reducing the harm of touching objects are also essential design principles. The use of safe and non-invasive soft materials as far as possible, the reduction of objects requiring complex cognitive judgement, and the translation of the frontiers of technology into designs that apply to the basic cognition of blind people allow them to experience the progressive development of the times together with them.

3.1 Artistic design that meets the cognitive characteristics of the blind

In outlining the design guidelines, it is essential to explain a little bit about what "art design that meets the cognitive characteristics of blind people" means. Only a minimal number of blind and visually impaired people in China have received systematic Braille study, and less than 940,000 people with visual disabilities have received a college education or higher, while the total number of people with visual disabilities in China is over 19 million. Among them, there are even more visually disabled people who were born blind. It is difficult for them to learn Braille systematically due to their age, family environment, and their reasons. Less than 0.04% of people in China can understand and recognize Braille.

At this stage, tools suitable for blind and visually impaired people to learn by touch should follow design principles. First, the design orientation needs to be based on the most sensitive sense of touch for blind and visually impaired people, plus the design characteristics of audio-visual perception as a supplement. It mainly involves cognitive tools that can assist them in art education and learning, spread the teaching of traditional Chinese culture, and is a form of general education to popularize art education. There is no restriction on whether one has a basic knowledge of Braille, and the design revolves around the shape of Chinese characters, graphic symbols, and Chinese Braille contrast. Secondly, the design should be simple and easy to understand. Based on the concept of universal accessibility design, it combined with the cognitive psychology of tactile cognitive characteristics, the "Design Progression" type of artistic processing, to generate to meet the cognitive needs of the blind and visually impaired people with different diseases. Finally, all designs are presented in three dimensions, which can also be transformed from two-dimensional to three-dimensional objects. The three-dimensional image is easier to perceive and learn by touch, and the cognitive memory of three-dimensional objects can be consolidated through repeated practice.

3.2 Promote the development of art education for the blind

The educational system for the blind should be simple. Students in special education schools need to acquire general knowledge to "survive in the world" and learn the skills to adapt to life as blind people. However, studies have shown that blind and visually impaired children at the age of 18 worldwide do not have the same level of skills as non-disabled children of the

same age. Those skill deficiencies, lack of teaching tools, and poor teaching methods have resulted in the vast majority of blind children having minimal access to jobs and employment in adulthood. The education they receive creates skill dysfunctions. Introducing art education for blind and visually impaired children is more effective. It frees them from the traditional limitations of "skill acquisition" and leads them to dynamic artistic thinking and creative ability. Blind and visually impaired people need to learn art because art is a spiritual vehicle for expressing emotions, soothing emotions, and expressing will and consciousness. Art is also said to be a human ecology and a continuation of life.

At this time, design is a clever way to intervene in the psychological subhealth of blind people with the help of Universal design, Barrier-free design, Inclusive design, and Design empathy. From the perspective of blind and visually impaired people, we will explore the value of design for people, give design humanity, emotion, and interaction, and design products, services, and systems that suit their needs in life. The lack of visual senses of the blind essentially limits the development of cognitive learning ability, and the tactile perception of objects has a particular bias, so the accurate expression of information transformed by the objects touched is crucial. Through the material, weight, temperature, shape, specification, and texture of the objects touched by the blind with voice-assisted explanation and environmental atmosphere creation, the blind can be assisted to the greatest extent in information collection and in-depth understanding of the art exhibits. At the same time, the development and design of tactile cognitive art products can serve as a tool to extend the functions of the human body and better reflect the new hope that the introduction of design brings to the expected life of the blind. It will serve as a practical form of assisting art education for the blind, reaching out to communities, blind associations, and clubs. It will enrich art education for the blind, enhance the cultural and artistic literacy of the blind, and enhance the creation of community and social friendship and mutual assistance.

3.3 Artistic output is easy to popularize and promote

Art products for the blind and visually impaired need to follow the design principles of "easy to obtain, easy to mass produce, and easy to popularize." Material selection should also follow the principles of "sustainable design" and "circular economy" in the design process to minimize manufacturing costs and reduce cost loss to achieve a higher penetration rate. This study has an inherent advantage in product design. The design of art cognitive products based on the sense of touch is suitable for blind and visually impaired people, using graphic symbols as design elements to build a new way of tactile cognition and reduce the "threshold" of cognitive learning. By recognizing simple graphics and symbols to achieve the purpose of cognitive learning, the new expression of tactile cognitive art can quickly enhance and broaden the cognitive scope of blind and visually impaired people in a "general knowledge, popular science, and common sense" way. By establishing a database of digital models of tactile cognitive art products, the research will collect design outputs and open models suitable for tactile cognitive products and aids and provide a database basis for implementing a design-sharing platform. To provide various options and references for selecting and updating art exhibits for the blind.

4. 3D printed Chinese character literacy art education tool for blind and visually impaired people

3D printing technology makes it easier to transfer Chinese characters from two-dimensional static images to three-dimensional images, making it more straightforward to learn to read

Chinese characters and to experience the joy of reading Chinese characters by touch (Figure 2).

Figure 2: Comparison of two-dimensional graphic and three-dimensional Chinese characters

4.1 *Hundred Family Surnames* Chinese character literacy interface

3D printing technology makes it easier to transfer Chinese characters from two-dimensional static images to three-dimensional images, making it more straightforward to learn to read Chinese characters and to experience the joy of reading Chinese characters by touch. The authors delve into providing a three-stage Chinese character literacy interface tool for the visually impaired with dot, line, and surface (Ji, R. & Sun, X. 2015). Drawing on the classic ancient Chinese Confucian writings, The *Hundred Family Surnames* is a learning tool for blind and visually impaired people to learn their Chinese surnames using the Chinese character order for the interface composition. It is the best reading material for the enlightenment of traditional Chinese culture and Confucianism, with a wide range of applications and covering many characters. The number of blind and visually impaired people who recognize the strokes of their surnames is almost zero. So adding this to art education, cognitive learning enhances motivation, increases curiosity improves mood, and boosts self-confidence.

In addition to learning Chinese characters, the corresponding Braille text using to assist in learning bump text. The interface size is standard A4 paper size 297mm×210mm, and the sample thickness is 1mm (Figure 3). Design 47 layouts using open-source fonts for typography, Chinese characters on the top, Braille on the bottom, Chinese characters on the left, and Braille on the right. So that blind and visually impaired people can learn Chinese characters and deepen their impressions of Braille simultaneously. The material used is PLA, a biodegradable and environmentally friendly material with low cost, which is suitable for special education schools and social welfare institutions to use on a large scale. PLA's unique additive linear printing texture is more suitable for touch learning and can physically increase tactile perception. The interface can be designed as a single unit according to the learning needs, achieving low cost and fast and precise tactile textures.

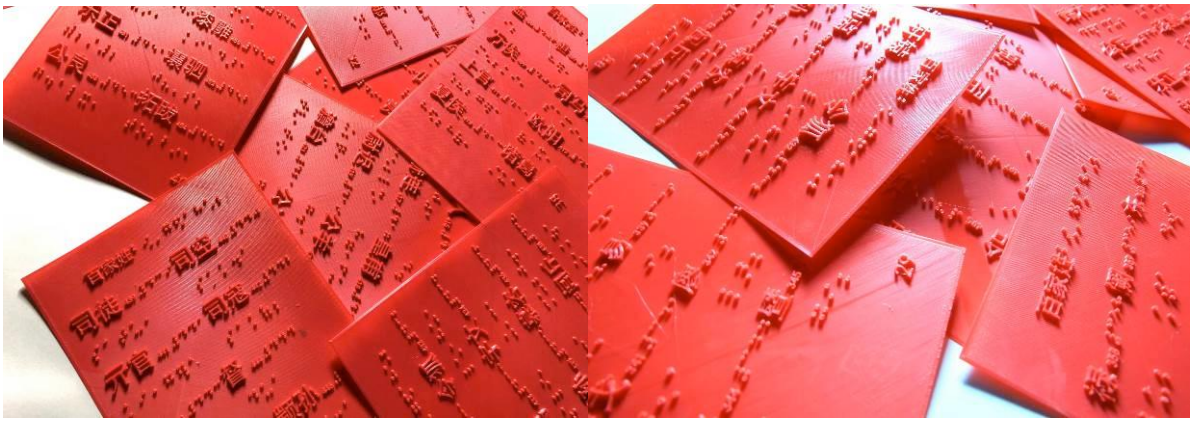

Figure 3: *Hundred Family Surnames* Chinese character literacy interface

4.2 Chinese character tactile cognitive name interface

Using the Chinese tool book Dictionary *CiHai* as the blueprint for the interface composition, words are substituted for characters to form a combination of words and phrases, and subjects' names are researched for artistic literacy interface design (Figure 4). The interface combines the landscape, geographic or hydrological features of the subjects' hometowns, which can serve to increase unique memory points and enhance the fun of learning Chinese characters, as well as briefly summarize the features of their hometowns and arouse their motivation and curiosity for learning. Recognizing people and names. Cognitive learning starts from names, and the tactile memory method can be better increased by touching cognitive learning of their names during the learning process and designing the Chinese character name literacy interface.

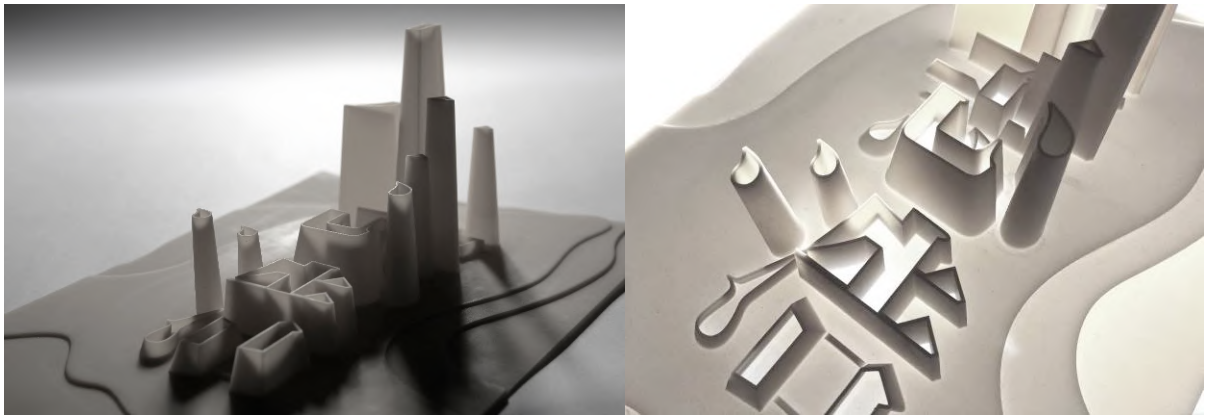

Figure 4: Chinese character tactile cognitive name interface *Li Zhihao*

4.3 Chinese combined character

Chinese characters have evolved throughout China's history, resulting in several symbolic and playful amalgamated characters. Also known as "auspicious characters," "auspicious words," and "auspicious combined characters," these combined characters are a combination or arrangement of several individual Chinese characters to form a graphic symbol with metaphorical characteristics. There are two types of characters, the upper and lower structure and the left and the right structure. Chinese characters contain national characteristics and unique character dismantling recognition. *Xu Shen* of the Eastern Han Dynasty elaborated on the six types of Chinese character creation in his *Origin of Chinese Characters*, narrative, pictorial, onomatopoeic, metaphorical, exegetical, and borrowing. The combined characters

are divided into graphic combined characters, symbolic combined characters, and metaphorical combined characters.

This literacy interface draws on the selected combined character redesign with sound blessing symbolism and adopts the realization method of 3D printing (Figure 5). The red color with traditional Chinese characteristics chosen, and the biodegradable PLA material with low cost, low manufacturing difficulty, and easy to be popularized among 3D printing materials (Figure 6).

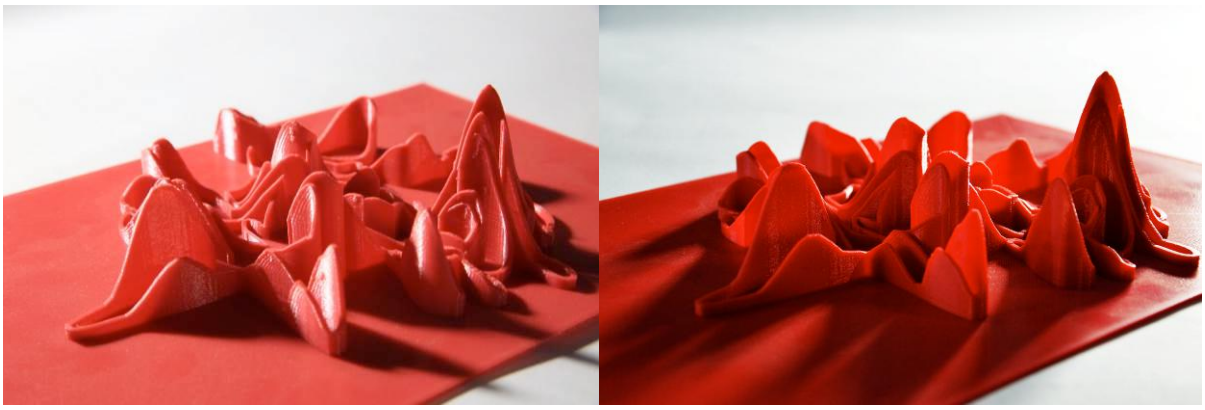

Figure 5: Chinese combined character name recognition interface '吉祥如意'

Figure 6: Chinese combined character name recognition interface '吉祥如意' front

The artistic and educational tool of the combined characters involves selecting more than 20 folk slang words with good blessings that Chinese residents often come into contact with in their daily lives. It also serves as a guide for spreading traditional Chinese culture,

popularizing national culture for blind and visually impaired people to improve national self-confidence, and guiding them to explore Chinese national culture more deeply.

4.4 Chinese poetry tactile cognitive interface

The Chinese character literacy interface for the blind already involves the cognitive learning of Chinese characters. We add the *Tang Poems* and *Song Lyrics* as the blueprint for the interface composition, selecting poems with high circulation and popularity, increasing literacy difficulty, enhancing the fun of reading tactile characters, and making it fun to teach (Figure 7). Studying *Tang Poems* and *Song Lyrics* not only enhances cultural cultivation and perpetuates and inherits traditional Chinese culture but also gives a deep sense of national identity and pride from thoughts. From the poems, we can feel the patriotic sentiment, the true meaning of life, the sense of life, the sun, moon, mountains and rivers, and the scenery of the country's north. From the poems, we can learn to enhance our sense of beauty and the exploration of finding beautiful things. The poems show the harmony between man and nature, the philosophical realm of spiritual resonance with the natural environment, and more. The poems will help us understand the true meaning of life. It can also help establish a positive outlook on life, values, and worldview and open the eyes to a balanced perception of universal things.

Figure 7: Chinese poetry cognition interface '*Tao Zhe*'

5. Conclusion

This research hoped to popularize art education for blind and visually impaired people in China, enhance the learning of traditional Chinese culture, enhance cultural literacy and improve the artistic aesthetics of people with disabilities, and provide a scalable design paradigm for the education of people with disabilities in China and globally. With Chinese character design as the starting point, the project explores new tactile cognitive art expression methods for the blind and forms art education tools through art design to reduce cognitive learning barriers and lower the threshold of cognitive learning. The resulting art products can be rapidly popularized through 3D printing to reduce production costs. The resulting digital model database can be shared to attract more "young aspiring" designers to join the project, drawing widespread attention from society and calling for equal treatment of people with visual disabilities.

References

Collins, J. J., Imhoff, T. T., & Grigg, P. (1996). Noise-enhanced tactile sensation. *Nature*.

Ji, R. & Sun, X. (2015). The Collision Between Tactile and Visual Theory of Braille and Chinese Characters of Oneness Design. *Design* (19), 19-21.

Lu Lai. (2021). Methods, Processes and Prospects of Braille Chinese Font Design. *Art Panorama (01)*, 166-168.

Roman, L. G. (2009). Disability arts and culture as public pedagogy. *International Journal of Inclusive Education*, 13(7), 667-675.

Zhang, X., Tian, J., Gao, T., Zhang, D., & Zhou, H. (2022). Tactile Cognition and Art Product Design for the Blind Based on Emotional Interaction. *In International Conference on Human-Computer Interaction* (pp. 233-238). Springer, Cham.

Contact email: xiaotongzhangwood@qq.com