A Review of Research on Digital Intergenerational Interactive Product Design from the Perspective of Intergenerational Integration

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Abstract. In this paper, a total of 86 research literatures on digital intergenerational interactive products at home and abroad have been sorted out in multiple citation indexes such as SSCI. It is found that the research content focuses on three aspects: service value, design development and design strategy of digital intergenerational interactive products. This paper focuses on the service value of digital intergenerational interactive products to empower the elderly, help children grow, and promote intergenerational integration, and puts forward important directions to be studied, such as satisfying personalized needs, enriching functional ecology, building promotion mechanisms, and forming systematic design strategies, for the product design and development of online platforms, smart devices, and virtual and real integration spaces, as well as emotional and gamified product design strategies.

Keywords: Intergenerational Integration; Digital Intergenerational Interactive Products; Value of Services; Design and Development; Design Strategy

1 Introduction

As a sociological concept, intergenerational integration refers to a state of internal cohesion between different generations that are actively interdependent, resource exchange, and life interaction and reciprocity. [1]In the era of digital intelligence, China is facing the challenge of population aging, the implementation of the three-child policy, reshaping the population structure, the change of social intergenerational relations and the evolution of life patterns have aroused widespread attention, and new challenges and opportunities have been put forward for the harmonious communication of different generations and the design of digital intergenerational interactive media products that meet the needs of intergenerational integration.

Digital intergenerational interactive products refer to tools or platforms that promote communication and communication between different generational groups based on digital technology, such as digital games, mobile applications, smart devices, and virtual and real fusion spaces. In order to explore the research status of digital intergenerational interactive products at home and abroad, this paper searches keywords based on "all years" in the citation indexes of CNKI (Peking University Core, CSSCI), SSCI, SCIE, EI, A&HCI, CCI, etc., with

the themes of "intergenerational/intergenerational/parent/parent/grandparent/child", "interaction/integration/communication/exchange", "digital/intelligence/electronic/virtual", "product/game/media/application/platform/tool", etc. As of April 2024, a total of 86 relevant articles have been sorted out.

2 Overview of the current status of the research

In terms of the number of literatures, 53 journals and 33 conferences were involved. Among them, the average annual number of articles before 2015 was less than 5, from 2015 to 2018 to 5, after 2019 to about 9, and there were two peaks in 2019 and 2022, as shown in Figure 1. The research content focuses on three aspects: service value, design development, and design strategy of digital intergenerational interactive products.
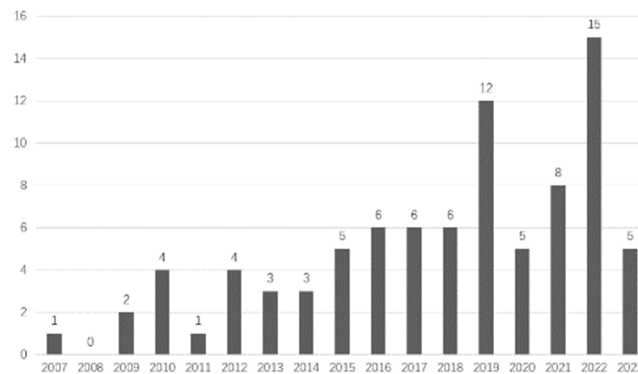
Fig.1 The average annual distribution of the number of articles

The institutions that published more than two papers were Yunlin University of Science and Technology in Taiwan, Mixed Reality Laboratory at the National University of Singapore, and the Open University in the UK;The authors of more than two publications are Professor Adrian David Cheok, founder of the Mixed Reality Lab at the National University of Singapore; Professor Natalia Kucirkova, Open University, UK; and Griffith, Shayl F., Department of Psychology, Florida International University, USA.Professor;The International ACM Conference on Interaction Design and Children (IDC) and CHI Conference on Human Factors in the conferences that included more than two papersComputing Systems (CHI), ACM SIGCHI Annual Symposium on Computer-Human Interaction in Play (CHI PLAY);THE journals that included more than two articles were Packaging Engineering, SUSTAINABILITY, LITERACY and UNIVERSAL ACCESS IN THE INFORMATION SOCIETY, with a total of 11 articles.Two of them studied the service value of digital intergenerational interactive products to intergenerational integration, six studied the design and development of digital intergenerational interactive products, and three studied the design strategies of digital intergenerational interactive products.

The research direction involves design, computer science, psychology, sociology, pedagogy and other disciplines, with distinct interdisciplinary characteristics.Among them, the number of papers related to design is the largest, focusing on the design process and design

strategy;Papers involving computer science focus on technical means;Psychology, sociology, education and other disciplines pay more attention to the experimental process and effect evaluation after design.

3 Service value of digital intergenerational interactive products

3.1 Empowering old age: learning new knowledge and emotional care

Digital intergenerational interactive products are effective carriers to meet the diversified needs of the elderly such as information acquisition, cognitive improvement and emotional care.Among them, as a representative product that enables digital intergenerational interaction, games can enrich the information technology experience and digital cultural life of the elderly, and enhance the communication and understanding between the elderly and the younger generation.

In terms of access to information, through intergenerational games, the elderly can easily access information and learn new knowledge.For example, Zhang, F. et al. (2017) adopted Wii Sports Resort, a sports simulation video game developed by Nintendo, to conduct a 6-week digital game social practice on 11 pairs of elderly people (65-92 years old) and college students (18-25 years old). [2]The study found that it enriched the lives of the elderly and improved their information technology literacy.

In terms of emotional care, by completing game tasks with their grandchildren, the elderly can strengthen their emotional connection with the younger generation. The Fantastic Journey, an intergenerational game designed by Cerezo et al. (2019), aims to give older people the opportunity to participate in the gaming lives of their grandchildren through intergenerational interactive experiences, incorporating them into digital culture and finding ways to improve cognitive function, overcome communication barriers and social isolation in older people. [3]

3.2 Helping Children Grow: Cognitive development and communication

The positive impact of digital intergenerational interactive products on children's cognitive development and parent-child communication has attracted extensive attention from scholars.Among them, tablet computer, as a digital device with strong interaction and rich content, provides children with diversified learning resources and strengthens parent-child communication and interaction.

In terms of cognitive development, digital intergenerational interactive products can effectively improve children's cognitive and language skills. For example, Kucirkova et al. (2015) deeply explored the knowledge construction and social interaction process of the tablet application "Our story" in the story creation between mother and daughter, revealing that the rich interactive elements provided by multimedia technology can change the parent-child communication mode in the context of traditional paper reading, and can stimulate children's cognitive reconstruction and innovative expression. [4]

In terms of parent-child communication, the application of digital intergenerational interactive products in the family can promote higher quality parent-child interaction. For example, Skaug et al. (2018) compared the differences between traditional media (toys, TV) and interactive

media (tablet games) in the quality of parent-child interaction between mothers and 2-year-olds, and found that compared with traditional toys and TV activities, tablet games can significantly improve children's social skills and promote parent-child communication. [5]

3.3 Promoting intergenerational integration: Bridging the gap and cultural inheritance

Digital intergenerational interactive products can strengthen intergenerational communication and contact, effectively bridge the communication gap caused by differences in technology and cultural background, promote knowledge transmission and cultural exchange, build a cultural inheritance bridge of cultural pre-feeding and cultural re-feeding, and promote intergenerational integration.

In terms of intergenerational communication, digital intergenerational interactive products, as a bridge of intergenerational communication, can promote intergenerational understanding and interaction and enrich communication experience.For example, Liang L et al. (2019) designed two intergenerational narrative products and proposed that enhancing intergenerational emotional connection and understanding through technological means can create an equal, interesting and educational interactive narrative environment, bridge the information gap and communication status difference between different age groups, and establish positive two-way communication between the two generations. [6]

In terms of cultural inheritance, digital intergenerational interactive products promote cultural inheritance and innovation through intergenerational communication, providing a new way for the young generation to contact traditional culture.For example, Chou, W. H. et al. (2022) integrate the elements of Taiwan's traditional puppet play into the design of virtual reality (VR) games, which vividly displays the experience of the older generation through innovative digital forms and attracts the active participation of the younger generation, thus promoting the continuation and development of traditional culture at the family and even social levels. [7]

It can be seen that digital intergenerational interactive products have played a positive role in empowering the elderly, helping children grow up, and promoting intergenerational integration. However, for young and middle-aged groups, whether these products can play the same positive role is still insufficient empirical research support. Therefore, it is necessary to deeply study the needs of young and middle-aged groups in the use of digital intergenerational interactive products, so that they can better serve all age groups.

4. Design and development of digital intergenerational interactive products

Relevant scholars have developed a variety of digital intergenerational interactive products that promote intergenerational relations, mainly from the perspective of focusing on children or the elderly. When focusing on children, it is mainly developed according to different ages of children, and some scholars focus on special groups of children such as children with diabetes, children with hearing impairment, and left-behind children. When the focus is on the elderly, there is little further segmentation of the elderly group. In terms of product types, it mainly focuses on the construction and optimization of online products, the innovation of

digital intelligence technology implantation of physical equipment, and the interactive exploration of virtual and real fusion space.

4.1 Construction and optimization of online products

In terms of the construction and optimization of online products, scholars have deeply explored the physiological and psychological characteristics of children and elderly groups, and designed and developed for themes such as education, health, leisure and entertainment, and emotional memory.

4.1.1 Focus on children's design and development

From the perspective of children, educational games, health products and leisure games are particularly prominent.

Educational games are mainly devoted to improving children's learning motivation and learning effect, and strengthening the emotional connection between parents and children through innovative gamified interaction forms.VocaMono (2013), for example, is a multiplayer educational game adapted from MonoPoly and Scrabble. [8] The goal of the game is to become the richest player, redeem in-game money and trade cards by spelling words correctly, and this mechanism is designed to effectively improve children's English word recognition and learning motivation.During the game, parents will give their children advice and help on spelling words, which promotes interaction and communication within the family.

Health products are mainly committed to promoting parent-child interactive exercise and improving children's physical activity levels and psychological conditions.For example, Family Move (2020) is a health and exercise mobile application, which encourages parents to actively participate in their children's daily exercise and healthy lifestyle. [9]The application includes video guidance, point system, level setting and other functions. Research finds that the intervention of Family Move has a positive impact on children's physical activity level.At the six-month follow-up, the children were found to have fewer psychosocial problems.

Casual games are designed to encourage family members to explore together and improve the quality of parent-child relationships.For example,Iga et al. (2017) developed a leisure digital scavenger hunt game tekuPico to improve the quality of parent-child relationship in the shopping environment. The game encourages children to follow their parents to explore together through the three stages of searching for treasure, approaching treasure and obtaining treasure in the shopping center, so as to collect treasure and enhance shopping experience. [10]

4.1.2 Focus on the design and development of the elderly

From the perspective of the elderly, emotional expression products occupy an important position, mainly focusing on the emotional memory needs of the elderly.For example, Li, C. (2019) designed and developed an intergenerational story sharing and preservation system for the elderly after five iterations, consisting of a slot machine-like device for the elderly and a mobile app for the young. [11]Promote effective communication between older and younger generations through story sharing, story preservation, and intergenerational collaboration.The virtual reality (VR) -based intergenerational interactive game developed by Chou, W. H. et al. (2022) is based on a cooperative and sharing mechanism, enabling the elderly to act as the role

of imparts experience and knowledge to guide the younger generation to contact and understand the traditional culture of Taiwan, as shown in Figure 2.

Fig. 2 VR interactive game with the theme of Taiwan's traditional puppet show

However, the shortcomings of existing products are mainly reflected in the depth and breadth of segmented demand mining, and how to provide personalized product experience is a big challenge. In terms of technology application, how to balance the immersive experience brought by new technologies (such as VR) with the acceptance and operation convenience of elderly users is also a problem worth paying attention to.

4.2 Innovative design of smart devices

In terms of the innovative design of smart devices, scholars focus on considering the use scenario of smart devices, and ensuring the availability of functions and ease of operation, so that the devices can better adapt to the needs of users of different ages and enhance the interaction effect between generations.For example, in the design of a game platform to enhance intergenerational interaction, Khoo et al. (2009) developed an intergenerational interaction platform named Age Invaders by integrating mixed reality technology and human movement tracking technology. Considering the constraints of the home environment, the system builds an interactive floor platform by using reconfigurable square tiles. [12]To accommodate different sizes of rooms.Players move across the floor and interact with the game through physical movements, encouraging family members to participate in physical activities together, as shown in Figure 3.

Fig.3 Age Invaders

Academics are also relying on technologies such as the Internet of Things to build apps for smart devices.For example, the intelligent care interactive chair designed by Tseng, W. S. W.et al. (2019) can record and analyze the living habits data of the elderly, and children can

view their parents' usage records, weight records, abnormal use notifications and other data through the app, providing family members with an opportunity for emotional interaction and parent-child communication. [13]The parent-child interactive balance car designed by Li C. (2022) is used for parent-child interactive play in the scenic spot, equipped with data interaction, parent-child interactive games, emergency help system and other functions to improve the play experience of parents and children. [14]

However, in the development of smart devices, protecting user privacy, exploring seamless interaction between different devices and operating systems, how to integrate smart devices with social networks, so that family members can maintain close contact and interaction even in different locations are also important directions for future design development.

4.3 Interactive exploration of virtual fusion space

For the virtual and real fusion space, scholars mainly rely on the exhibition space represented by the museum or outdoor activity space, through the integration of objects and conditions in the space, to build an educational, interesting and collaborative interactive experience, and expand the realistic boundaries of intergenerational interaction.

Intergenerational interactive products that connect virtual and real can effectively enhance collaborative learning and communication between parents and children.The interactive desktop video game Shredding with Mom and Dad, designed by Dietmeier et al. (2017), provides a long-lasting parent-child interaction model for children's museums by creating a virtual skatepark on a desktop using physical blocks representing skate park elements. [15]The Sound Happening device developed by Long, D. et al. (2018) realizes the visualization and interaction of music creation with the help of sphere operation, encourages adults to actively participate in children's play activities in public space, and enriches the forms of parent-child interaction, as shown in Figure 4. [16]

Fig.4 Sound Happening

Mobile social gaming also opens up new possibilities for family cooperative play scenes outdoors and in public. MeteorQuest (2018) is a location-based mobile social game that encourages physical and social interaction between family members.Family members are divided into two roles: communicator and navigator. [17] The communicator is responsible for receiving and delivering game-related information, and the navigator is responsible for guiding the team in the right direction based on the communicator's information. This

mechanism is set up to facilitate family members' communication and exploration of the surrounding environment, as shown in Figure 5.

Fig.5 MeteorQuest

However, the downside of existing products is that they may be limited in scope, more focused on specific places such as museums or parks, and most rely on custom hardware or specific site conditions.In the future, more virtual and real experience should be developed for different places, such as schools, community centers, libraries and other public Spaces; Develop portable virtual-real fusion devices or applications that enable intergenerational interactive experiences anytime, anywhere, regardless of venue constraints; Simplify technology applications, reduce the reliance on custom hardware, and make it easy for more homes and institutions to use.

5. Design strategies for digital intergenerational interactive products

5.1 Emotional design: emotional connection and experience deepening

Emotional Design is a design concept proposed by Donald Norman that aims to stimulate an emotional response from users through the design elements of a product or service, thereby enhancing the user experience, building brand loyalty, and promoting a positive and lasting connection between users and the product.

Many scholars advocate the use of emotional design in the design of digital intergenerational interactive products and parent-child products.For example, Nie Q.et al. (2015) should apply the emotional design method in parent-child products to explore and meet the emotional needs of users in an all-round way from the three levels of instinct, behavior and reflection, so as to promote family harmony, enhance parent-child relationship and improve user experience. [18]Zhang W. et al. (2023) proposed that the design of intergenerational narrative products for the elderly should start from the intergenerational narrative context, and extract their emotional needs into remembering the past, education inheritance and companionship, and realize the integration of product coding and emotional decoding through innovative mapping to the three levels of product design: instinct level, behavior level and reflection level.Help the elderly to obtain positive and rich intergenerational emotional experience in the process of use. [19]

In general, emotional design has become one of the core design strategies of digital intergenerational interactive products. Scholars strive to deepen emotional connection and interactive experience through emotional resonance and communication, so as to create high-quality products that not only meet the needs of humanity but also have high social integration.

5.2 Gamification design: interactive stimulation and fun integration

First described by British engineer Nick Pelling in 2002, Gamification is the transference of the best principles of game design to non-game situations and products in order to increase user engagement, enhance the experience, and inspire intrinsic motivation.

In recent years, this concept has also been widely used in digital intergenerational product design, and game mechanisms such as incentive, feedback, and competition have promoted different age groups, especially children, to participate more actively and happily in intergenerational interactions.For example, Liu, Q. et al. (2015) studied the application of gamification design in parents' participation in the speech training system for hearing-impaired children. [20] By setting achievements and rewards, parents and children are encouraged to complete specific training goals together.The emphasis on successfully embedding game elements into the otherwise boring rehabilitation training process can effectively arouse the learning enthusiasm of hearing-impaired children and reduce the pressure of parents. Han, X. et al. (2022) proposed an innovative parent-child physical activity intervention model based on smartphone apps, which stimulates the participation interest of children and parents through parent-child cooperation and goal-oriented game-based elements, effectively promoting the physical activity level and physical fitness improvement of preschool children and their parents. [21]

In the gamification design of digital intergenerational interactive products, scholars also pay attention to the importance of parental participation. Pappa et al. (2020) explore the importance of parental roles in serious games designed to improve children's physical and mental health, tailored to the specific challenges faced by children and their parents, with due consideration for key mechanisms of parental involvement. [22]

However, the future needs to continue to optimize gamification design, avoid mechanical stacking of game elements, such as points, levels, etc., to ensure that it remains moderately challenging and meets the psychological needs of different generations, and truly achieve the core goal of improving intergenerational interactive experience.

5.3 Exploration of other strategies: concept expansion and multiple innovation

Scholars also put forward a variety of strategies such as integrating family values, participatory design, and positive emotion design, which promoted the design concept innovation of digital intergenerational interactive products.

For example, in terms of design value presentation, D'Cruz et al. (2015) emphasized that digital intergenerational interactive products should integrate family values and respect parents' right of guidance in children's growth. [23]At the level of participatory experience, Naranjo-Bock et al. (2017) proposed that we should attach importance to and promote shared participatory experience, allow intergenerational participation in the content creation process, and provide different levels of participation options to adapt to parents and children with different skill levels. [24]In terms of design framework, Chen, K. (2022) proposed positive emotion design strategies with expectation, happiness and trust as the core to support children's cognitive development and improve the quality of parent-child relationship. [25]

Future exploration of multiple design strategies should continue to strengthen interdisciplinary cooperation in order to obtain more comprehensive research perspectives and deeper

theoretical insights, so as to promote the multiple development and practical application of design strategies.

6 Conclusions

Digital intergenerational interactive products cover a wide range of user groups from children to the elderly, meeting the interactive needs of people of different ages in education, health, leisure and entertainment, emotional communication and other aspects, and playing an important positive role in cultural inheritance.The current product types mainly include online products, intelligent devices, and virtual reality fusion space.Online products focus on providing diversified services under the intergenerational interaction scene; Smart devices focus on the usability and convenient operation of products, and strive to design efficient intergenerational communication tools; The interactive exploration of virtual and real fusion space combines physical space resources to promote intergenerational shared learning and collaboration through innovative experience methods. In terms of product strategies, emotional design, gamification design and other strategies are widely used to enhance the emotional bond and interesting participation of intergenerational interaction, and improve user experience and product attractiveness.

However, there are still some gaps in the existing research.First, the elderly group is considered as a whole, which fails to fully subdivide its age level and lacks more targeted products. Second, people generally pay attention to the use experience of the elderly and children, while relatively little attention is paid to the young and middle-aged groups.Third, how to motivate users to actively participate in the mechanism of intergenerational interaction is not clear.Fourth, the systematic design of digital intergenerational interactive products has not yet been formed, and there is a lack of in-depth discussion and theoretical construction of intergenerational integration.

Therefore, this paper believes that the future digital intergenerational interactive product design needs to pay attention to four aspects: first, it should focus on in-depth understanding and meeting the individual needs of different generations of users, and enhance the practical value and social value of digital intergenerational interactive products;Second, combine emerging technologies to create a richer product form and content, and enrich the functional ecology of digital intergenerational interactive products;Third, explore the intergenerational interaction promotion mechanism in depth, and explore how to stimulate the willingness to participate in and sustained interest in intergenerational interaction through incentives, feedback systems, social identification, reward mechanisms and other means.Fourthly, it combines the theory of intergenerational integration with multidisciplinary theories such as psychology, sociology and pedagogy to form a more systematic design strategy in design practice.

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