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Transdisciplinary Design Research of Homebound Seniors

Wen Huei Chou[1], Ya-ling Ko[2], and Chung-Wen Hung[3]

[1]Department of Digital Media Design, National Yunlin University of Science and Technology, 123 University Road, Section 3, Douliou, Yunlin 64002, Taiwan, R.O.C
[2]Department of Design Research, National Yunlin University of Science and Technology, 123 University Road, Section 3, Douliou, Yunlin 64002, Taiwan, R.O.C
[3]Department of Electrical Engineering, National Yunlin University of Science & Technology, 123 University Road, Section 3, Douliou, Yunlin 64002, Taiwan, R.O.C

ABSTRACT

To provide high-quality home-based activities for the elderly, this research project emphasizes the integration of expertise from three distinct fields: digital design, electrical engineering, and occupational therapy. Our goal is to leverage interactive gaming technology to minimize the technological burden and fully utilize the convenience of intelligent networks, offering a drumming game tailored for older adults. This game is designed to help them maintain social interaction, stimulate cognitive abilities, and promote physiological functions in their daily lives. Throughout the study, we facilitated transdisciplinary collaboration to achieve the goal of healthy aging and well-being, while also evaluating the effectiveness of such collaboration during the research process. Furthermore, we analyzed the collaborative mechanism for transdisciplinary integration, aiming to enhance the overall cooperation outcomes.

Keywords: Transdisciplinary design, Seniors well-being, Human centre design, Interaction design, Drumming game

INTRODUCTION

The aging population grapples with numerous daily challenges, particularly social isolation, emotional loneliness, and the decline of physiological and psychological functions. Research emphasizes the impact of social isolation on older adults' health and well-being (Cudjoe et al., 2020; Perkins et al., 2016) and links social isolation and emotional loneliness to increased depression, cognitive decline, and poor mental health outcomes (Masi et al., 2011; Ong et al., 2016). Declining physiological functions, such as mobility, strength, and balance, are also common challenges faced by the elderly (Milanović et al., 2013). This decline can result in increased risk of falls, injuries, and reduced independence, exacerbating feelings of isolation and loneliness (Yardley et al., 2006). Additionally, the aging process often leads to cognitive decline, impacting memory, attention, and problem-solving abilities (Zokaei et al., 2017).

Interventions targeting social, emotional, and physical aspects of aging are essential for maintaining older adults' overall well-being (Nimrod et al., 2020). Research suggests that physical activity, social engagement, and cognitive stimulation can effectively mitigate aging's negative effects on physiological and psychological functions (Hwang, Park, & Kim, 2018). Thus, developing comprehensive approaches addressing elderly individuals' multifaceted challenges in their home environment is crucial.

Older adults face various technology adoption challenges, including cognitive barriers, operational complexity, and fear of new technologies (Czaja et al., 2019; Marston et al., 2016; Neves et al., 2018). Employing user-centered design and incorporating design research principles can improve technology accessibility for this population (Elboim-Gabyzon et al., 2021; Vines et al., 2013). Involving older adults in the design process allows developers to better understand their needs, preferences, and limitations, leading to more intuitive and age-friendly digital solutions (Brankaert et al., 2015; Wild et al., 2020).

Transdisciplinary collaboration can encounter numerous challenges, such as communication barriers, differing terminologies, and cultural differences among professionals from diverse fields (Feng, & Kirkley, 2020; Newman, 2023). Integrating expertise from engineering, healthcare, and digital design is particularly challenging due to diverse methodologies and perspectives involved (Celi et al., 2015; Cozza et al., 2021). However, interdisciplinary research is necessary for generating innovative solutions addressing complex societal problems like aging and healthcare provision (Wang et al., 2020).

Various music therapy approaches underscore drumming's significance as an early human musical activity transcending cultural and historical barriers (Amad et al., 2017; Roy, Devroop, & Bohn, 2019; Miyazaki et al., 2020). Recent studies explore drumming's role in promoting social engagement and emotional well-being for older adults (Bensimon et al., 2008; Fancourt et al., 2016). Drumming interventions have shown improvements in cognitive function and upper limb mobility for older adults with cognitive impairments, and enhanced motor skills and coordination in aging populations (Miyazaki et al., 2020). Drumming strengthens individuals' stability and control through basic rhythms, and positively correlates with improved sensorimotor integration and complex motor execution (Hsu et al., 2021).

Our research sought to promote healthy aging and well-being by fostering transdisciplinary cooperation and refining collaborative frameworks for interdisciplinary integration. To this end, we developed a user-centered interactive drumming game as an intervention approach, investigating its impact on older adults' physiological, psychological, and social aspects. This multifaceted approach involved several stages, such as designing a drumming course, planning and creating a multiplayer online drumming game, and incorporating sensing device systems (Fig. 1). By employing this comprehensive strategy, we aimed to enhance elderly well-being and facilitate the achievement of successful aging benefits.

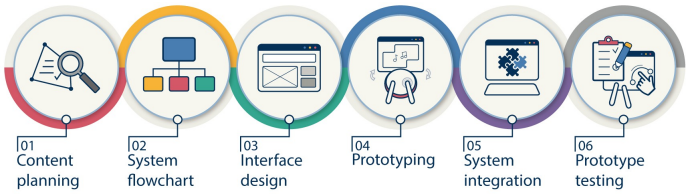

Figure 1: Research and implement process.

RESEARCH AND TRANSDISPLINARY DESIGN PROCESS

Experts Focus Group Interviews

In the research stage for designing a drumming course for older adults, we conducted focus group interviews with five experts experienced in teaching such courses. The focus group interview lasted approximately two hours, and after the interview, the experts' opinions were summarized verbatim. From their insights, we identified key design elements for the drumming game: (1) Offer opportunities for personal skill display and reward mechanisms, providing feedback and levels after system evaluation; (2) Give immediate, clear feedback including visuals, text, and scores; (3) Set various difficulty levels catering to different players; (4) Increase fault tolerance by adjusting the detection area of the striking zone; (5) Offer diverse options, including unlocking songs, and single or multiplayer games; (6) Incorporate teamwork through multiplayer modes; (7) Meet target players' needs by selecting emotionally resonant songs; (8) Utilize mnemonic devices or visual features to enhance learning, with intuitive designs; (9) Plan a progression from basic to advanced; (10) Retain physical teaching functions, limiting sessions to 40–50 minutes. The online course mode accommodates seniors affected by the pandemic or with limited mobility, enabling teachers to monitor their learning status via video calls.

UX and UI Design

We employ a Samsung Tab A7 tablet with a 10.7-inch touch screen running on the Android system and is developed using the Unity game engine. Following the flow chart, interface visual design is conducted with a focus on the elderly, a target group that presents unique challenges due to physiological, cognitive, and computer usage experience limitations. These challenges are closely related to age-related changes in perception, physiology, psychology, and cognition (Chang et al., 2018). To accommodate the needs of the target group, specifications are made for font, color combinations, and button settings (Fig. 2 & 3).

1. Font size and vocabulary Adapting to age-related physiological declines, such as weakened vision, is crucial. Font size impacts users' understanding of functions. Both overly bold and thin fonts can hinder readability for the elderly. Scholars Zongliang (2020) recommend using Heiti and sans-serif fonts with regular thickness. Font size varies depending on the interface medium, with 20pt being commonly used. For standard tablet

sizes, Kaufman, Suave, & Ireland (2020) suggests a 23pt font size. This study sets the font size at 40pt or larger to reduce reading errors. In-game wording aims to be familiar to the elderly, emphasizing accuracy to minimize operational misunderstandings and boost willingness to use.

2. Color planning Age-related vision decline affects dark adaptation, visual processing speed, and perceptual flexibility (Iancu & Iancu, 2020). Color recognition and sensitivity change with age, with colors serving as a distinguishing and identifying feature in interfaces (Pereira et al., 2021). In color planning, attention should be paid to weaker contrasting objects, which may be harder for older individuals to discern. Additionally, degeneration of the eye's lens selectively absorbs blue light, reducing blue light discrimination ability (Zongliang et al., 2020). Thus, blue colors should be minimized. Contrasting colors help enhance visual functions, especially for those with lower visual sensitivity (Morey et al., 2019). This study focuses on highly recognizable and contrasting colors, with a low-brightness beige background and high-saturation buttons and patterns. Warm colors, such as red and gold, are primarily used, followed by green, to establish recognizability and utilize contrasting colors for improved visibility.
3. Physiological decline also affects fine motor skills, potentially limiting gestures like dragging and pinch-to-zoom (Chang et al., 2018). This study minimizes the need for such gestures, focusing on simple ones like single-tapping, accompanied by auditory feedback. Indicator symbols are used for button design, fixed in the upper left corner of the interface. Button size and spacing impact elderly users' ability to learn and interact with the interface. Lin & Ho (2020) suggests a minimum button size of 9mm x 9mm for tablet interfaces, while Yu et al. (2022) examines the impact of physical conditions on touchscreen use for elderly and middle-aged groups, finding that buttons positioned at the top of the screen and sized at 16mm are ideal. This study follows these guidelines and adds a button size adjustment feature as recommended by Petrovčič et al. (2018) for improved usability for elderly users.

Figure 2: Enter and setting pages of Drum game.

Figure 3: Interface design of Drum game.

System Development

This research introduces a drumming apparatus that fuses both physical and virtual aspects, leveraging interactive technologies, remote instruction, and the ideas of a virtual orchestra. The objective is to facilitate the rapid acclimatization of elderly individuals to an interactive drumming educational setting, diminish the learning pressures, and boost their upper body muscle power and overall physical health. The ultimate aim is to reconcile the divide between traditional and virtual drumming encounters.

The hardware aspect of the solution amalgamates conventional drumming practices with sensory equipment and IoT technologies. In contrast, the software component utilizes the Unity game engine for the creation of cross-platform interactive materials. The Samsung Tab A7 tablet serves as the digital interface, and the apparatus is engineered for both tactile striking and distant interaction, guaranteeing an instinctive user experience while fostering upper body strength and physical health.

The research incorporates a CC2541 Bluetooth module for the application of IoT technology and sensor apparatuses. The drumming instrument encompasses a tangible drum structure and drumsticks, utilizing piezoelectric sensors for the detection of vibrations on the drum surface. These sensors produce equivalent positive and negative charges upon the application of force, assisting in pinpointing the exact locations of drum strikes.

including traditional taiko drums, electronic drums, and alternative drum surfaces produced by laser cutting. The final design choice is a laser-cut alternative drum surface, which is appropriate for domestic use and offers precise feedback. The middle layer undergoes alteration from foam to a hollow configuration with screws, with the aim of minimizing the contact area with the base. A piezoelectric sensor is affixed to the rear of the drum surface to pinpoint the strike locations. Given the device's dimensions, air drumsticks are employed for the drumming game. The AeroBand PocketDrum is selected as the primary air drumstick, which captures data and ascertains the strike locations during game play. Integrated Bluetooth modules relay data to Unity, thereby activating the sensing area of the UI interface. For the chronological progression of hardware device research, please refer to Figure 4.

Figure 4: The design evolution of percussion instruments, the tractional drum (left), sensor devices and IoT technology applying on volume-improved version of the drum (upper right), and the air drumstick drum game device.

CONCLUSION

This study successfully developed a home-based group drumming course for the elderly, as a comprehensive and effective solution which supports the health and social connection of the elderly population. This drumming game integrating virtual and reality actives five effective results outcomes for elderly, contains social, irrational, and psychological functions (Fig. 5).

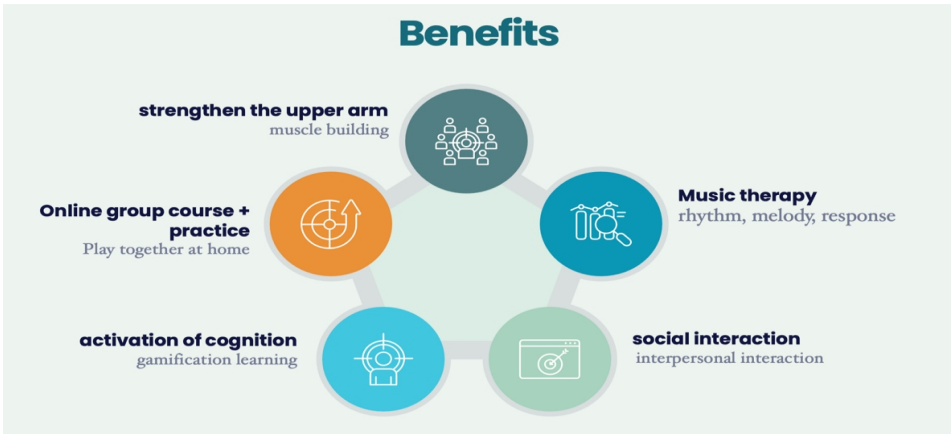

Figure 5: Five effective results outcomes.

The transdisciplinary collaboration, rather than linear, focuses on user-centered design as a prerequisite. To achieve the primary goal of providing

occupational therapy interventions for the elderly, professionals from various fields must continuously communicate and discuss, ensuring a shared understanding of the issues and coordinating responses to different adaptive challenges, developing a comprehensive solution, then ultimately perfecting the design proposition. In the foreseeable future, real-world problems require more interdisciplinary collaboration, breaking the boundaries of traditional learning paradigms and complementing each other to seek the greatest social welfare (Fig. 6).

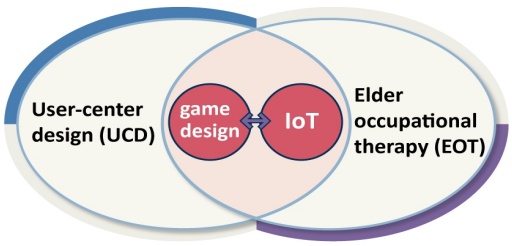

Figure 6: Transdisciplinary collaboration structure.

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