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Analysis of Key Design Criteria in The Application of Virtual Reality Technology Towards Social Interaction for The Elderly in China

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ABSTRACT

Virtual Reality (VR) technology holds significant potential for enhancing social interaction among the elderly. It can effectively improve their quality of life and reduce feelings of loneliness. Through VR environments, elderly individuals can participate in various social activities and rehabilitation training, which not only enhances their well-being but also positively impacts their physical and mental health. However, many older adults continue to experience reduced social engagement due to physical limitations and environmental constraints. Research on the specific applications and effects of VR technology on elderly social interaction particularly in China remains limited. This study aims to identify key design criteria for VR-based social interaction platforms utilising Human-Computer Interaction (HCI) tailored for elderly users. Data were collected from 82 participants aged 55–80 in Hefei and Nanjing of China, through an online questionnaire. The study explores user experiences and preferences, as well as strategies for optimising VR platforms for elderly social engagement. Findings indicate that effective VR platforms must incorporate optimised design elements, content features, and service components to promote usability and sustained engagement. The results offer valuable insights for VR platform designers, developers, operators, and end users, guiding the initial planning and ongoing improvement of such platforms. Additionally, the study highlights the influence of operational strategies on long-term platform success.

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INTRODUCTION

While digital media technologies have seen considerable advancement and application in supporting elderly populations, in-depth studies specifically focusing on how virtual reality (VR) can facilitate social interaction among older adults remain limited. This gap is particularly evident in addressing the unique cognitive, emotional, and physical needs of ageing individuals within virtual environments. Considering this, the present study undertakes a comprehensive examination of how VR technology can be effectively utilised to enhance social interaction for the elderly. It aims to explore not only the functional potential of VR but also the limitations, barriers to adoption, and user-centred design considerations necessary for successful implementation. Guided by this objective, the study seeks to answer several key research questions: in what ways can VR technology address and fulfil the social needs of elderly users? How effective is VR in enhancing social interaction among older adults, and what evidence supports this? What challenges – technological, cognitive, or cultural – hinder elderly engagement with VR platforms? How can the design and implementation of VR systems be optimised to better serve the ageing population? Through these inquiries, the study contributes to the growing body of knowledge on ageing and technology, offering practical insights for developers, designers, policymakers, and caregivers striving to create more inclusive and impactful digital environments for elderly users.

Problems and Challenges

Virtual Reality (VR) technology offers an innovative solution for enhancing the daily lives of older adults, particularly within smart home environments. It enables seniors to break the monotony of routine, increase life satisfaction, and improve overall well-being. For instance, Arlati et al. (2019) developed "Social Bike," a VR-based application designed to enhance the clinical outcomes of frail elderly individuals through at-home physical activity. Similarly, Shao & Lee (2020) extended the Unified Theory of Acceptance and Use of Technology (UTAUT) model based on interviews with both experts and elderly users to better understand how social VR can impact older adults' social lives. Samta Kathuria et al. (2022) explored the role of mixed reality in promoting the health and well-being of seniors by integrating elements of competition, social interaction, and engaging multimedia content to stimulate physical activity. Fu et al. (2022) further suggested that immersive experiences in the metaverse – enabled by blockchain and intelligent networking – warrant deeper investigation to unlock their full potential in elderly care applications.

Despite these promising developments, several barriers hinder the effective integration of VR in social interaction for older adults. Technological challenges remain a major concern. As highlighted by Chen Lei (2023), many elderly individuals lack familiarity with new digital technologies and require considerable time and effort to learn and adapt to digital interfaces. Cultural and social resistance also plays a role; older individuals, often embedded in more traditional social contexts, may be less open to the digital culture that VR and similar technologies represent.

Moreover, as Liu et al. (2018) pointed out, the growing complexity of social media due to the abundance of features presented on single interfaces can be overwhelming for older users, leading to confusion and reduced engagement. Bowen & Wen (2021) emphasised that the natural decline in physical and cognitive function associated with ageing, such as memory loss and decreased information processing capacity, further complicates the use of new media. Additionally, exposure to unsolicited content (spam) and the risk of misinformation can discourage older adults from fully engaging with digital platforms.

The existing body of literature, as noted by Shao & Lee (2020), lacks focused discussions on the acceptability and influencing factors specific to social VR use among the elderly. Most current VR social platforms, including VRChat, Rec Room, and AltspaceVR, are primarily designed for younger users and

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lack features adapted for ageing populations. Yuxing et al. (2021) similarly observed that these platforms are rarely optimised for elderly users' needs, and Yuxing et al. (2021) stressed the importance of ageing-oriented design to enhance usability and comfort for older adults.

Encouragingly, some companies are beginning to address this underserved demographic. For example, You & Cho (2023) reported on the development of RendeverFit, a VR fitness platform specifically designed for seniors. The platform supports physical activity through immersive exercise modes while also fostering social interaction, addressing both physical and emotional needs.

In conclusion, although VR technology has demonstrated wide-ranging applications and considerable promise, its specific role in enhancing social interaction among the elderly remains underexplored and underdeveloped. Practical issues such as technological accessibility, usability, health concerns, and design limitations persist. Nonetheless, a growing awareness among research institutions and enterprises in China and beyond signals the beginning of a broader movement toward inclusive design. The present study aims to address these research gaps by providing empirical evidence and actionable insights to inform the development of age-friendly VR platforms, offering valuable guidance to developers, healthcare providers, and policymakers working in this field.

LITERATURE REVIEW

Overview of Virtual Reality Technology

Lowood (2024) defines Virtual Reality (VR) as an advanced method of human-computer interaction that simulates a three-dimensional virtual environment through the integration of computer and sensor technologies. According to Zhang (2005) the term VR—coined by VPL Research Inc. and Jaron Lanier in 1989—typically refers to a system of hardware and software involving helmet displays, sensor gloves, and other interactive tools. These devices allow users to issue commands using natural movements and receive real-time multisensory feedback, including visual, auditory, and tactile responses. As users move and interact, the feedback adapts, creating a dynamic and immersive experience.

Ma & Shi (2017) categorises VR systems into four primary types: immersive, desktop, shared, and augmented reality systems. These platforms are characterised by three main features—immersion, interaction, and imagination. Through various input devices, users can interact naturally with virtual objects, enabling them to explore, observe, and manipulate virtual environments to create experiences beyond those possible in the physical world.

Liu et al. (2018) note that VR creates a rich, multisensory virtual environment through real-time interaction, allowing users to perceive spatial and logical relationships. Yang et al. (2017) further highlight the convergence of VR with new media applications, citing emerging modes such as VR journalism, VR messaging, VR shopping, and gaming, each expanding the boundaries of imagination and digital engagement. Rong & Jiarui (2023) emphasises VR's compatibility with social-emotional learning frameworks, suggesting it offers a safe, engaging, and emotionally supportive environment for training in empathy, emotional regulation, and interpersonal skills.

From an ageing perspective, several studies have explored VR's potential to promote well-being among older adults. Lee et al. (2019) developed a framework to evaluate the effectiveness of VR and Augmented Reality (AR) in enhancing the health and social connectivity of the elderly. Huygelier et al. (2019) assessed attitudes toward immersive VR among 76 older adults with no prior exposure. Their findings indicated a

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shift from initial neutrality to positive attitudes following first-hand experience. Wu Lin (2022) contextualises this within broader social dynamics, noting that physical ageing, chronic illness, changes in work status, retirement, and shifts in family structure all contribute to a reduction in social interaction for older adults.

This is corroborated by Czaja et al. (2006), who assert that increasing concerns about social isolation coincide with the growing ubiquity of digital technologies. Although these tools transform social interaction across all age groups, older adults often face cognitive and physical barriers that hinder their ability to adopt and use them effectively. These include manual dexterity challenges, memory limitations, and difficulties navigating complex interfaces.

The literature on VR's social applications for older users reveals two dominant perspectives. On one hand, studies like Arlati et al. (2019) emphasise VR's role in physiological well-being through applications like "Social Bike," a gamified exercise platform. On the other hand, Shao & Lee (2020) focus on psychological outcomes, using the extended UTAUT model to demonstrate how social VR can alleviate loneliness by influencing user behaviour. While both perspectives are valuable, they rarely intersect to explore how specific design features of VR platforms might directly contribute to emotional and social well-being.

Interestingly, Huygelier et al. (2019) found that first-time users tended to respond positively to VR, contradicting earlier assertions by Chen (2023) and Qian (2023), who argued that elderly users experience a "technophobia-cultural disconnect." This discrepancy may stem from differing sample groups—where the former involved more active, tech-curious seniors, the latter drew from populations with limited digital literacy. Such findings suggest that the acceptance of VR is significantly influenced by users' prior experience, physical health, and baseline technological competence, making it difficult to generalise findings across all elderly groups.

Recent innovations have begun to address these issues. You & Cho (2023), for example, introduced RendeverFit, a VR platform designed specifically for older adults. It simplifies interaction by replacing traditional gestures with voice commands, thereby reducing barriers to use. However, such simplification may come at the expense of functional richness, leading to what the authors term "function castration" or a loss of innovation.

Moreover, Shao & Lee (2020) observed cultural variations in VR adoption. Their Korean-based study suggests that strong family ties encourage VR acceptance among older adults, a finding not emphasised in Western contexts like that of Huygelier et al. (2019). This highlights the importance of considering cultural dimensions in the design and implementation of VR applications for elderly users.

METHODOLOGY

Research Method

This study employs a mixed-methods approach, combining quantitative and qualitative techniques to systematically analyse data collected through structured questionnaires. The survey was administered using Questionnaire-Star software and distributed through both online and offline channels. Online distribution targeted seniors aged 55 to 80 in Hefei and Nanjing via universities for the elderly, community activity centres, and senior-focused social media groups. Offline outreach was conducted in public spaces such as parks, hospital waiting areas, and community health centres, where eligible participants were invited to

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complete paper-based questionnaires. Of the 100 questionnaires distributed, 82 were returned and deemed valid, resulting in an effective response rate of 82%. The final distribution ratio was approximately 70% online and 30% offline.

Hefei and Nanjing were chosen as sample cities due to their contrasting demographic and socio-economic profiles, providing a balanced representation of urban ageing in China. Hefei, where individuals aged 55 and above account for 28.5% of the population in the year 2023, exceeds the national average of 18.7%, indicating a significant ageing demographic. Known as the "Vice Centre" of the Yangtze River Delta, Hefei has received substantial policy support for VR/AR innovation—particularly through initiatives like the “Silicon Valley of CSU”—yet it exhibits relatively low adoption of geriatrics-focused technology, making it a relevant context for identifying early barriers to diffusion. In contrast, Nanjing represents an economically advanced urban area with a more mature digital ageing infrastructure. With 31.7% of its population over age 55 according to data from the Nanjing Municipal Bureau of Statistics (2024), the per capita GDP in year 2023 was 174,000 yuan. Nanjing was among the first to be designated as a “National Smart Elderly Demonstration Base.” Its well-established VR applications in community ageing care offer a valuable benchmark for comparative analysis.

Given the study’s aim to identify and prioritise key usability and design challenges, quantitative analysis was appropriate for measuring the experiences, attitudes, and preferences of elderly users across various dimensions of VR interaction. As Creswell & Cresswell (2018) emphasises, quantitative methods are especially suitable for capturing relationships between demographic variables—such as age, education level, and technology acceptance—through large-sample data and statistical validation. Complementing the quantitative data, qualitative analysis was used to extract deeper user insights. Open-ended responses were coded thematically, revealing underlying issues such as usability constraints, health-related concerns (e.g., dizziness or fatigue), interface accessibility (e.g., font size, icon clarity), and user expectations regarding VR platform features. These qualitative insights provided a richer understanding of user behaviour and expectations, enabling more informed recommendations for design optimisation.

To ensure the reliability and validity of the questionnaire, a pre-test was conducted with a small sample of older adults. Adjustments were made to question wording for better comprehension, and a balanced-option strategy was employed to minimise leading bias. The final questionnaire consisted of two major components: Part One focused on user experience with VR hardware and platforms, assessing variables such as operational difficulty, physical comfort, preferred functionalities, and willingness to pay. Items covered design elements such as system complexity, interface clarity, and adverse effects (e.g., vertigo). Part Two addressed user needs and attitudes toward VR platforms, including intended use (e.g., social interaction, learning, entertainment), security concerns, payment thresholds, and comparisons with traditional social technologies.

Quantitative analysis involved calculating response frequencies and proportions to identify priority areas for improvement. Key challenges were ranked based on prevalence, enabling targeted design recommendations. Meanwhile, qualitative responses were categorised into recurring themes that offered context-specific insights into senior users’ pain points, preferences, and aspirations for VR engagement. Together, these methods provided a robust framework for evaluating the effectiveness and inclusiveness of current VR systems for elderly users, as well as informing the development of age-friendly digital environments.

Study Limitations and Directions for Improvement

There is a potential bias in focusing this study only on older adults in the urban area of Hefei and Nanjing, as there are significant differences between urban and rural Chinese older adults in terms of digital

literacy, economic level, and health status, and urban data alone may overestimate the universality of VR technology. In the future, if the results of this study are to be extended to a wider group of older adults, consideration should be given to including rural participants to gain a more comprehensive perspective. In the future, the sampling scope can be expanded through cooperation with township health centres.

RESULTS AND DISCUSSION

Pre-survey Reliability Test

The reliability of the scale was tested through a pre-survey before the questionnaire was formally distributed. The questionnaire was pilot tested among 40 older participants to improve wording and ensure comprehension. The pre-survey sample consisted of a total of 30 older adults aged 55-80 years in Hefei and Nanjing, and convenience sampling was used. The questionnaire contained sixteen (16) question items covering the dimensions of operational difficulty, health impact, and functional requirements. Cronbach's alpha coefficient was used to assess internal consistency. The results showed an overall scale reliability of 0.79 (> 0.7); structural validity was verified by exploratory factor analysis (EFA), with a KMO value of 0.78 (> 0.7) and a significant Bartlett's test of sphericity (χ^2=336.5, $p<0.001$). Principal component analysis was used to extract three common factors, with a cumulative variance explained ratio of 67.3% and factor loadings of each item > 0.5. Based on the results of the pre-survey, two cross-loaded items were deleted, resulting in a fourteen (14)-item scale that is suitable for assessing the experience of elderly users of VR technology. The form was reviewed by three experts to confirm that the questions covered the core dimensions of virtual reality use, including use purpose, interface improvement, and help channels. The multiple-choice question options cover entertainment, socialisation, learning and health needs, which are supported by the literature and meet the needs of older users.

Demographic Results

Table 1. Demographic of the Participants

Variable	Description	N	(%)
Age	55-60	21	25.61
	61-65	25	30.49
	66-70	19	23.17
	71-75	9	10.98
	76-80	8	9.76
		82	100
Gender	Male	33	40
	Female	49	60
		82	100
Education Leve	Junior school and under	29	35.37
	Technical secondary school	47	57.32
	University and above	6	7.32
		82	100

Source: Authors (2026)

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Table 1 presents the basic demographic information of the 82 elderly participants in the study, including age, gender, and education level. In terms of age distribution, participants aged 61–65 accounted for the highest proportion (30.49%), followed by those aged 55 to 60 (25.61%) and 66–70 (23.17%). Fewer participants were over 71 years old, indicating that the sample primarily consisted of younger and middle-aged seniors. Gender distribution showed that female participants (60%) outnumbered males (40%). Regarding education level, most participants had a secondary education background (technical secondary school or equivalent, 57.32%), while 35.37% had a junior high school education or below, and only 7.32% had a university degree or higher. This reflects the generally low educational attainment among the elderly in the sample. These data provide important contextual insights for subsequent analyses of elderly users' experiences and needs regarding VR technology.

Analysis of Elderly's Experience and Social Interaction in Using the VR Application

According to the first part of the questionnaire, the frequency of each tag used by the participants about VR devices and platforms was counted, and the proportion of each tag was calculated, and the results are shown in Table 2.

Table 2. Feedback from Participants on the Use of Virtual Reality Devices and Platforms

Variable	Disagree (N/%)	Average (N/%)	Agree (N/%)	Strongly Agree (N/%)
Do you find it difficult and complicated to use VR equipment?	19/ 23.17	15/18.29	29/35.37	19/23.17
Willing to try using VR technology?	18/21.95	21/25.61	33/40.24	10/12.20
Worried about the impact of using a virtual reality device on your health?	11/13.41	12/14.63	37/45.12	22/26.83
Do you feel dizzy or uncomfortable when using a VR device?	19/23.17	18/21.95	40/48.78	5/6.10
Do you think the graphics of VR platforms are as real as the real world?	21/25.61	19/23.17	28/34.15	14/17.07
Happy with the VR platform's interface?	16/19.51	26/31.71	26/31.71	14/17.07
Is it a good interactive experience in a virtual reality platform?	17/20.73	27/32.93	25/30.49	13/15.85
Are you concerned about the property security risks associated with VR technology?	5/6.10	12/14.63	30/36.59	35/42.68
Do you feel that the digital media social platforms on the market are not enough, and hope that more technology platforms will appear?	16/19.51	32/39.02	20/24.39	14/17.07

Source: Authors (2026)

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According to the second part of the questionnaire, the frequency of each label was counted, and the proportion was calculated. The table's reliability (KR-20 ≈ 0.82) question consistency was strong after pre-survey analysis. The table was confirmed through three (3) experts review that the questions cover the core dimensions of VR use, including usage, purpose, interface improvement, and help channels. The question options cover entertainment, socialisation, learning, and health needs according to the literature support, which is in line with the needs of elderly users.

Table 3: Participants' Opinions on the Use of the VR Platform

Variable	Description	N	(%)
How would you like to approach and use the VR platform?	VR Glasses	10	12.20
	VR App	35	42.68
	VR Software	25	30.49
	VR Game	12	14.64
		82	100
What is your purpose in using a VR platform?	Entertainment and leisure	38	46.34
	Interact with Family and friends	19	23.17
	Learn new knowledge	16	19.51
	Fitness rehabilitation	9	10.98
		82	100
In what ways do you think the interface design of VR can be improved to make it more ?		38	46.34
	Large font size	24	29.27
	Simple steps	10	12.20
	Less advertising		
	Easy access to human customer service	10	12.20
		82	100
If you have any questions or confusion about VR platforms, where would you most like them to be answered?	VR device manual	8	9.76
	Family members	41	50.00
	VR Community Forum	3	3.66
	Human customer service	30	36.59
		82	100
If there is a fee for the use of a virtual reality platform, how much are you willing to pay for it?	<¥100	26	31.71
	¥100-200	24	29.27
	¥200-500	18	21.95
	¥500-1000	9	10.98
	>¥1000	5	6.10
		100	100

Source: Authors (2025)

A total of 82 valid questionnaires were collected in the formal research, and the reliability was tested by KR-20 coefficients (for dichotomous variables) and Cronbach's α coefficients, and the validity was verified by validated factor analysis (CFA). The overall scale KR-20 = 0.85 and Cronbach's α = 0.82, indicating high reliability of the scale. The results of CFA showed good model fit indices ($\chi^2/df = 2.15$, RMSEA = 0.06, CFI = 0.93, TLI = 0.91), a range of standardised factor loadings from 0.62 to 0.88 (>0.5), and combined reliability (CR) were all >0.7, and average variance extracted (AVE) were all >0.5, meeting

the requirements. The square root of AVE for each dimension was greater than the inter-dimensional correlation coefficient, indicating good discriminant validity. (Table 4)

Table 4. Differential validity test (comparison of AVE square root and correlation coefficient)

Dimension	Operational complexity	Health risks	Functional Requirement
Operational complexity	0.81	0.32	0.25
Health risks	0.32	0.78	0.18
Functional requirement	0.25	0.18	0.84

Source: Authors (2026)

Findings

According to the results of the questionnaire, it was found that the complexity of operation has become the primary obstacle for older users to integrate into VR social platforms. The research data shows that as many as 58.54% of the respondents believe that the operation of VR devices is complicated, which is not only reflected in the initial aspects such as wearing the device and launching the software, but also in the subsequent operation process, such as interface navigation, function selection, etc., and the complexity of the steps and logic discourages older users. Meanwhile, 23.17% of respondents clearly expressed resistance, reflecting that the difficulty of operation has become a threshold that cannot be ignored. In addition, elderly users are generally worried about the health impact, 71.95% of users expressed concerns about the use of VR devices may bring vertigo and other health problems, of which 48.78% of users did feel dizzy in actual use, this proportion is more significant in the age group of 71 to 80 years old, reaching 68.75%, indicating that with the growth of age, the elderly users' concern for health is increasing. The immersive nature of VR devices may exacerbate their health risks. There is an obvious mismatch between market supply and demand from elderly users.

Most of the VR social platforms on the market are designed for young people and lack an age-adapted design for older users. For example, the interface fonts are small, the navigation level is complex, and the icons are difficult to understand, which are not in line with the cognitive characteristics and usage habits of elderly users. Meanwhile, the existing platforms fail to provide sufficient support for the strong demand of elderly users for virtual family gatherings, health management and other scenarios. In the survey, 80.49% of the respondents expect an exclusive ageing-friendly platform to meet their specific social and health needs. Financial costs and safety concerns are also important factors inhibiting older users' willingness to pay. It shows that 31.71% of elderly users are only willing to accept a payment range of less than RMB 100, and more than 60% are unwilling to pay more than RMB 200. Meanwhile, 42.68 % of users are strongly worried about property risks, and 79.27 % are cautious about paying for fear of fraud, reflecting the distrust and insecurity of older users in digital payments.

Analysis of Main Criteria Related to Key Design Criteria of VR Social Interaction Platform with VR Human-Computer Interaction (HCI) for Elderly Usage

Based on the questionnaire survey, it was found that there are three main criteria related to the key design criteria of a social interaction platform with VR Human-Computer Interaction (HCI) for elderly usage. Table 5 is the summary of survey results:

Table 5. The main criteria for the elderly to use virtual reality social platforms

Main criteria	Components
Design Elements	Clear and legible interface design
	Large fonts and icons for easy recognition
	Simplified interface and simplified operation process,
	Fewer advertisements
	Easy access to customer service.
Content Elements	Provide Diversified Social Scene
	Creating Virtual Communities
	Set up Interactive Games
	Provide Virtual Travel Experience
	Virtual Fitness Activities
	Health Consultation
Service Elements	Online Courses and Lectures
	Engage multiple parties in the development of digital products and services for the elderly
	After-Sales Support
	Reduce the Economic Costs
	Guarantee Data Security

Source: Authors (2026)

Design Elements

Based on the survey, the respondents mentioned that it reflects the ease of use, the interface design is clear and easy to identify, large fonts, large icons are appropriate, including the simplification of the graphical interface and the simplification of the operation process, easy to operate, less advertising, can be convenient to contact the human customer service. This is supported by Qiu Junping (2008) that mentioned about the ease of use of VR, which is a requirement for the user's ability to use the platform. Platform the lower the requirements for user competence, the easier the platform will be to use. Li (2004) believes that how users view the screen, how to understand the icons, how to find the icons, in what situation the user is prone to error, and what are the characteristics of the user's learning process, the human-computer interface designer should obtain this knowledge through the user operation survey.

The platform needs to provide a simple and easy-to-use interaction design, so that the elderly can easily operate in a virtual environment and enjoy the fun of social interaction. Yu-Huan et al. (2022) recommended to use more soft colours in the software interface, and the colours should not be too much. Try to be as concise, familiar, and make it easy for users to remember, less visual fatigue. Use more well-known graphic language to replace complicated text language and simplify it. Highlight the actual meaning, avoid ambiguity, reduce the user's learning, and reduce the burden of memory. The overall layout should be steady, no jump too much, not too prominent, and reduce excessive visual stimulation. Ensure the consistency of the interface.

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Content Elements

Choi et al. (2023) pointed out that factors such as personal cognition, VR content, social aspects, and HMD-related elements had explanatory power of 35.1%, 10.7%, 4.4%, and 2.5%, respectively, for the continuous usage intention of HMD-based VR content. Feng & Murakami (2021) believe that telling stories is an indispensable method of human communication. Stories can express emotions, teach methods, and provide experiences. Therefore, the research of narrative theory is essential for any media production. Holdack (2021) argues that the content-related variables perceived playfulness and perceived informativeness appeared as important predictors for attitudes and behavioural intentions when researching VR experiences.

Based on the literature analysis, it was found that the criteria were divided into 6 as follows:

(i) Provide Diversified Social Scene

Wenhong & Yi (2021) believes that, unlike the previous video or live broadcast applications that were mainly based on one-way recording, and different from flat video calls, video interaction will move towards more directional, three-dimensional, and real scenarios, such as realising VR social networking. Lee et al. (2019) confirmed that materials delivered through 360-degree VR content are more focused, immersive, and engaging than 2D mode. Xiuyun et al. (2013) mentioned several measures to improve the diversified virtual social space for the elderly, such as: setting up interactive games, basic topic quizzes, FAQs, and other columns to comment and browse some members, creating a good interactive atmosphere, and establishing an effective reward system.

Using VR technology rich social circles can cover the old man in social, health, learning, entertainment needs, for the elderly with distant relatives and friends' communication, interaction, also can let the elderly according to interests choose to join different social circles, meet like-minded friends, to ease their loneliness. For example, Lin (2023) mentioned that RendeverFit is a fitness platform specially created for the elderly, using VR technology, assisted by visual, audio, and somatosensory signals, to create three major game modes such as cycling, paddle and painting, to help the elderly solve psychological loneliness, improve mood, and exercise hand and foot coordination. RendeverFit makes full use of the rich experience and social desire of the elderly, in different virtual modes and scenarios, the elderly can share their own experiences to achieve social establishment with other groups, reduce anxiety and loneliness, and reintegrate into the world more confidently and equally.

(ii) Creating Virtual Communities

Rheingold (1993) defines a virtual community as "a group of people who communicate with each other primarily through the Internet, who know each other to some extent, share knowledge and information, and care for each other to a large extent as if they were friends", Henri & Pudelko (2003) divide virtual communities into four main types: interest communities, goal-oriented interest communities, learning communities, and community practices.

In virtual reality, a virtual community can be created specifically for seniors, allowing them to engage in hobbies and social activities such as attending parties, dancing, playing cards, etc., as if they were in the real world.

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(iii) Set up Interactive Games

Feng & Murakami (2021) through experiments, it was demonstrated that the means that the subjects can remember the most information is a VR news game with a storyline. Shao & Lee (2020) suggest that social VR systems such as remote meetings, social games, and group recall can be developed to alleviate cognitive decline in the elderly.

The platform should provide a variety of interactive games, such as virtual reality version, chess, etc., so that the elderly can enhance friendship in the game interaction, and improve the activity coordination ability of hand, eye, and brain, and promote healthy development.

(iv) Provide Virtual Travel Experience

Guttentag (2010) believes that the most common use of VR in the tourism sector is to enhance tourism experiences for attractions. Already in 1962, theme parks started to establish multisensory experiences such as simulated rides in 3D and VR are frequently used in museums or exhibitions to convey additional information or make objects interactive, such as the Virtual Stonehenge. Sussmann & Vanhegan (2000)'s study showed that political or environmental instabilities may force customers to make new decisions and adapt their travelling style to the circumstances by using VR. He pointed out that the potential advantage of virtual travelling is the opportunity for disabled tourists, bringing the travel experience to those who are unable, or find it inconvenient to travel due to physical disabilities or debilitating illnesses. Jeng et al. (2017) found that the behavioural intentions of the elderly when experiencing VR leisure activities highlight enjoyment as the major aspect, indicating that when the elderly find an activity that is interesting and relaxing, it helps to improve health. Shu (2021) believed that virtual tourism breaks the limitations of time and space and reduces the travel cost of consumers, such as virtual play, online tour guides, shopping, and role substitution.

So many elderly people may not be able to travel long distances due to physical reasons, by using specialised VR devices, such as head-mounted displays or handheld controllers, to can enter the virtual environment and visit. These devices often feature a high-resolution display, stereo sound, and a comfortable wear design to provide an immersive experience. They can experience the scenery and culture from around the world just at home.

(v) Virtual Fitness Activities

According to Liu et al. (2018), VR technology is beginning to be increasingly used in the field of rehabilitation. Rehabilitation systems based on VR technology often have the characteristics of feedback, safety, controllability, etc., which can provide patients with interesting interactions, encourage patients to actively participate in rehabilitation training, carry out repetitive exercises, and help patients successfully complete various boring rehabilitation treatments. Shao & Lee (2020) believe that the social VR helps break through physical limits; such outdoor activities as rock climbing, tracing the river, and canoeing can be achieved through virtual environment. In the past, the elderly tended to be less likely to engage in activities because of physiological states or physical conditions, or because of their self-esteem for fear of troubling others. However, the use of social VR today breaks these limits or eliminates worries and gives them the confidence to participate in different social activities. In addition, Shao & Lee (2020) also mentioned that because of COVID-19, the

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elderly were forced to cancel the activities for their physical conditions or long distances. However, the application of social VR can solve this problem and construct a social interaction state in another virtual space environment.

VR technology can simulate a variety of fitness activities, and VR technology can provide new ways for the elderly to participate in fitness and rehabilitation activities. They can do physical exercise, physical therapy, and cognitive training through virtual scenes, while participating with other older people, increasing the opportunity for social interaction, and doing effective exercise at home.

(vi) Health Consultation

Shao & Lee (2020) believe that physical medical behaviour in some conditions, or technology has not been overcome, physical conditions and medical behaviour are the inevitable activities, the long-distance virtual medical treatment and rehabilitation. Health treatment can be carried out in an immersive environment, or whether further treatment can be carried out in a home environment or in a nearby hospital.

Chen (2023) pointed out that platform should provide health consultation services, including online consultation, health lectures, as to help the elderly pay attention to their health. VR technology can be used in psychotherapy, for anxiety, depression and other elderly psychological problems, this non-invasive treatment may be more comfortable and effective. Improving their physical and mental health, regulating their emotions, and living their lives, also contributes to their physical and mental health.

Service Elements

Yuanrong (2023) defines service elements as the necessary determinants of services, which mainly include elements such as resources, people, technology, and management in digital services. Shu (2021) divided the elements of improving digital services for the elderly into four dimensions, including optimising the digital access environment, carrying out information skills and literacy training, taking incentive measures and developing digital products and services suitable for the elderly. Wu Lin (2022) suggested that in the design of the digital technology application model for the elderly, the cognitive ability of the elderly, their demand for the use of digital technology and the experience of the service environment should be combined to design a scientific and effective model with the goal of diversification, adaptation to the elderly, and benefit the elderly. Convenient access to digital technology services is the basic guarantee to strengthen the willingness of the elderly to use them.

Based on the literature analysis, under service elements, it was found that the criteria were divided into 5 criteria as follows:

(i) Online Courses and Lectures

Shu (2021) suggested that opening courses online and designed for convenience elderly people in Hong Kong can learn information technology without leaving home. With the theme of "Seniors IT is easy to learn." (https://www.it2.gov.hk/tc/index.php.) for example, the platform provides online course content including online shopping, E-government services, cyber security, cloud tools and social media, etc. These online courses interact with elderly in a variety of ways, such as mutual questions, virtual reality videos, etc.

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The platform should provide use training and operational guidance to help the elderly better master virtual reality technology. For online classes and lectures with a VR app on your smartphone or tablet. These apps often offer a similar feature to dedicated devices but require built-in cameras and sensors to track the user's head movements and gestures.

(ii) Engage multiple parties in the development of digital products and services for the elderly

Shu (2021) believes that digital products and services suitable for the elderly are an important part of the active ageing of the digital society and suggests that they should be established at the social, economic, and cultural levels through the promotion of exhibitions and the establishment of funds a more extensive and close linkage relationship has further enriched elderly's lives. The connotation of integration expands the extension of the digital integration of the elderly and broadens the digital integration of the elderly is essential for promoting the life of the elderly and the digital community. The deep integration will have a positive guiding value for the relevant solutions landing and development in the local area, so that more elderly people can be healthy, comfortable and a secure digital environment provides support for a comfortable old age.

(iii) After-Sales Support

Fisk et al. (2009) asserted that comprehensive after-sales support is crucial for ensuring that older adults can use VR social platforms in the long term and with peace of mind. Their research indicates that ongoing technical support and training are significant factors in the successful adoption and continued use of new technologies by the elderly. Shao & Lee (2020) argue that the physical health and fear of falls in older adults affect the frequency of purchases by older adults, so there is a high probability that older adults use VR for shopping. In the future hardware interface design, more consideration should be given to the convenience of social virtual reality and the possibility of service demand. The platform should provide perfect after-sales support to ensure that the elderly enjoy high-quality social interaction services.

(iv) Reduce the Economic Costs

In a study on the factors that influence users to buy VR equipment, Choi et al. (2023) found that the most important factors influencing users' acceptance and intent to purchase VR wearables include the expectation of the price of the technology. It is necessary to keep prices within the acceptable range for the elderly. Judging from the survey data, the acceptance of the price of VR equipment by elderly users is not high, therefore, how to make more elderly people accept and widely use such products, reduce costs, and increase efficiency may be a necessary measure in the future.

(v) Guarantee Data Security

Yan (2019) believes that there are some hidden dangers in the use of digital media by the elderly, such as over-reliance on family members' teaching, passwords that are not regularly changed or easily forgotten, low use of security software, and poor protection of personal privacy. Data encryption, identity authentication and access control, it is necessary to improve the protection of data security for the elderly from the technical level and social care and education level, such as: big data and cloud computing to prevent information leakage,

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research and development of special apps for the elderly, enhance media publicity, neighbourhood mutual assistance and other related measures, protect the data and information security and privacy of the elderly and avoid the elderly from becoming the target of network fraud.

(vi) To sum up, the key elements of the application of the social interaction platform for the elderly based on VR technology include design elements, content elements and service elements. Only by fully considering these elements can we provide a high-quality and convenient social interaction platform for the elderly.

CONCLUSION

The study identifies three key design criteria—design elements, content elements, and service elements as essential for developing effective VR social interaction platforms for the elderly. These criteria address the unique needs and challenges faced by older adults, such as operational complexity, health risks, and the demand for immersive social experiences. By simplifying interfaces, diversifying content, and enhancing support services, VR platforms can significantly improve the quality of life for the elderly.

Despite these advancements, barriers such as technological adaptation difficulties, economic costs, and safety concerns must be addressed to ensure broader adoption. Future efforts should focus on creating more inclusive and user-friendly VR solutions that cater to the physical, cognitive, and emotional needs of the elderly. Ultimately, this research underscores the transformative potential of VR technology in fostering social connectivity, mental well-being, and active ageing, paving the way for a more inclusive digital future for older adults.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Yan Yan was responsible for research design, data collection, analysis, and manuscript drafting. Natasha Khalil proposed the core research concept and constructed the theoretical framework. Mohammad Ali oversaw research design and supervised research progress. Siti Noorfairus Che Abdullah participated in

data validation, formal analysis, and manuscript review. All authors collectively reviewed the research findings and finalised the manuscript.

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