



A Study on the Design of Smart Healthcare and Wellness Spaces Empowered by AIGC and VR: An Integrated Approach to Sustainability, Cultural Heritage, and Digital Education Innovation

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Abstract. The design of smart wellness spaces currently faces three major challenges: an inherent contradiction between the widespread application of smart technologies and sustainable development goals; a disconnect between a function-first design approach and the need for cultural preservation, and the difficulty in transforming high-quality design outcomes into digital educational resources due to a lack of effective dissemination channels. This study uses the "Rui Ling An Ju" integrated design scheme as a practical vehicle to explore an integrative approach: in the stages of spatial planning, material selection, and scenario planning, sustainable concepts, cultural elements, and educational functions are incorporated as intrinsic elements into the design framework from the outset. Subsequently, a technical framework combining AIGC-assisted scheme generation and VR-based immersive validation is established to conduct performance simulation, experience optimization, and knowledge encapsulation of the design scheme. The study demonstrates that the approach of "goal-integrated design framework + technology-enabled validation and dissemination" can effectively create smart wellness spaces that combine environmental friendliness, a sense of cultural belonging, and educational exemplarity. This initiative provides a reference model for interdisciplinary research and practice in related fields.

Keywords: Smart Healthcare and Wellness; Sustainable Design; Virtual Reality; Cultural Heritage; AIGC; Digital Education

1 Introduction

According to data from the National Bureau of Statistics, by the end of 2025, China's population aged 60 and older had reached 323.38 million, accounting for an increasing share of the total population, with those aged 65 and older numbering 223.65 million[3]. As the technologies involved in designing smart wellness spaces continue to converge, the challenges have become increasingly complex, leading to a threefold dilemma. The first imbalance is the lack of sustainability in smart spaces. The model of "prioritizing

hardware over the ecosystem" conflicts with the nation's "dual carbon" goals. Smart technology should not be synonymous with high energy consumption[1]. Second, there is a disconnect in cultural heritage within senior-friendly environments, as many wellness and care facilities tend to take on a "hospital-like" or "hotel-like" character—prioritizing functionality and efficiency with clearly defined spaces, yet lacking warmth and stripping away family memories and local character[2]. While functional needs are met, the spiritual dimension remains unaddressed. The third imbalance lies in the lack of a voice for digital education in design communication. Those projects that prove successful after completion often remain confined to the physical space, lacking effective channels to transform them into interactive, shareable digital educational resources. Design wisdom is locked within the bricks and mortar, yet it remains unextracted, uncommunicated, and unpassed down.

This study proposes and implements an integrated approach: using the "Rui Ling An Ju" integrated design scheme as a platform, it explores how AIGC (generative artificial intelligence) and VR (virtual reality) technologies can empower the entire design process, bridging the gap between physical spaces and digital education[6], by integrating design practices, technical validation, and knowledge dissemination, we provide systematic solutions to enhance the quality of smart wellness spaces.

2 Speaking Past Each Other: The Disconnect Between Sustainability, Culture, and Technology in Wellness Research

2.1 Research on Sustainable Design: Energy-Intensive "Pseudo-Green" Solutions

Driven by the "dual carbon" goals, the academic community has conducted extensive research into the sustainable design of smart senior care spaces. However, a deeper issue has been overlooked: environments maintained at constant temperature and humidity rely heavily on mechanical systems, and their high energy consumption creates an inherent contradiction with the concept of low-carbon living. Sustainable technologies often function as standalone engineering modules, making it difficult to integrate them deeply with the nuanced, age-friendly, and barrier-free user experience. While technology is present, nature is absent[4].

2.2 Research on Cultural Implantation: Symbolization and "De-Familialization"

As greater attention is paid to the emotional needs of the elderly, the integration of cultural elements and "nostalgia therapy" have become hot topics of research. However, a closer examination of the aforementioned cases reveals that, in the pursuit of management efficiency, these spaces generally adopt a standardized "hotel-style" design. The space has become a cold, lifeless shell devoid of personal stories, making the elderly feel like visitors rather than people who truly belong[2]. It is evident that cultural applications today often amount to little more than superficial decorative symbols—

hanging a landscape painting on the wall or placing a piece of antique-style porcelain in the corner is enough to be called "culture". Such superficial incorporation fails to construct a "spatial narrative" with healing value, and emotional value has been marginalized in the tide of standardization.

2.3 Research on Digital Media Applications: Visual-First, Logic-Lacking

As virtual simulation and VR technology become increasingly widespread in universities and commercial settings, digital media is reshaping the way we perceive space. VR-powered "virtual property tours" have broken down spatial and temporal barriers, enabling designers and students to "enter" healthcare and wellness facilities that are difficult to visit in person, thereby transforming design concepts from static drawings into dynamic scenes[7]. However, this raises a problem: many existing applications fall into the trap of prioritizing visuals over logic. In the transition from "technology-enabled" solutions to "human-machine integration", if we overlook the agency of older adults and the logic of their daily lives, technological practices risk becoming overly instrumental and may even lead to new forms of digital exclusion[5].

2.4 Commentary: The Need to Move from "Isolated Islands" to Integration

A review of the aforementioned studies reveals a clear conclusion: while the academic community has achieved results in the areas of individual technologies for smart senior care, sustainable materials, and theories of emotional design, these achievements remain distinctly isolated from one another. Technical research overlooks the human touch, cultural research lacks empirical validation, and sustainable design remains detached from the user experience of older adults. Each operates along its own track, with little overlap.

3 Anchoring at the Source: Shaping Spaces for Sustainability, Culture, and Education

The design of "Rui Ling An Ju" began with a simple question: What kind of space does a person need as they grow older? This issue may seem simple at first glance, but it is complex upon closer examination. It involves physical decline, psychological changes, the preservation of memory, and the possibilities of social interaction. After careful deliberation, we established a three-pronged design framework: "a sustainable foundation of safety and dignity, a spatial poetics nourished by culture, and an interpretive educational model". The goal is to build a dynamic residential system that facilitates a seamless transition from healthy, comfortable living to age-appropriate care—a space designed not for "the elderly", but for "people who are growing older".

3.1 Sustainable Spatial Anchoring

The design rejects energy-intensive active systems, returning to the building's fundamental structure and the concept of age-friendly design, and explores a sustainable path characterized by low maintenance and a long lifecycle. To address the essential need for spatial accessibility among wheelchair users, the "circulatory flow" strategy is adopted to break down traditional partitions, with passageways reserved at a width of ≥ 900 mm. Software simulations show that this strategy utilizes the principle of thermal pressure ventilation to increase indoor natural air exchange rates by 25% and reduce summer air conditioning energy consumption by approximately 15%–18% [10]. Experimental data shows that cork flooring has a shock absorption rate 60% higher than that of standard ceramic tiles, reducing the risk of injury from falls among the elderly while embodying the eco-friendly philosophy that "materials equal safety" [8].

3.2 Spatial Translation of Cultural Heritage

How does culture find its way into a space? Not through a mere accumulation of symbols, but through the creation of a sense of atmosphere. In response to the growing spiritual and cultural needs of the elderly, design should reject the excessive use of symbols and instead draw on colors and atmospheres from traditional Chinese aesthetics to create a "haven of peace" with healing properties.

3.2.1 Creating an Atmosphere Through Color and Texture.

Research shows that over 65% of older adults rate neutral warm tones as providing a greater sense of psychological security. Based on color psychology and the physiological characteristics of aging vision (yellowing of the lens and decreased sensitivity to blue and violet light), (as Figure. 1) the spatial tone is positioned as "warm". Low-saturation traditional Chinese colors such as amber yellow, cinnabar red, lotus-pink, and bean-paste green are used to create a healing environment with emotional warmth. These colors are understated yet pleasing to the eye. They are not vivid, but they are calming.

3.2.2 Incorporating Culture into Daily Activities.

The underlying logic of the spatial layout is a response to traditional lifestyles. The "Zowang Study" model shifts the focus of the living room from the television to a generously sized writing desk. Featuring a mortise-and-tenon design with armrests, the desk is designed with sufficient clearance (≥ 700 mm under the table) to accommodate wheelchairs, supporting activities such as calligraphy and painting that cultivate the mind and spirit, and reviving the cultural legacy of "farming and reading as a family tradition". The "Gardening for Pleasure" model features tiered, multi-level planting racks, allowing elderly residents in wheelchairs to easily prune and water plants, thereby maintaining a connection between people and nature.

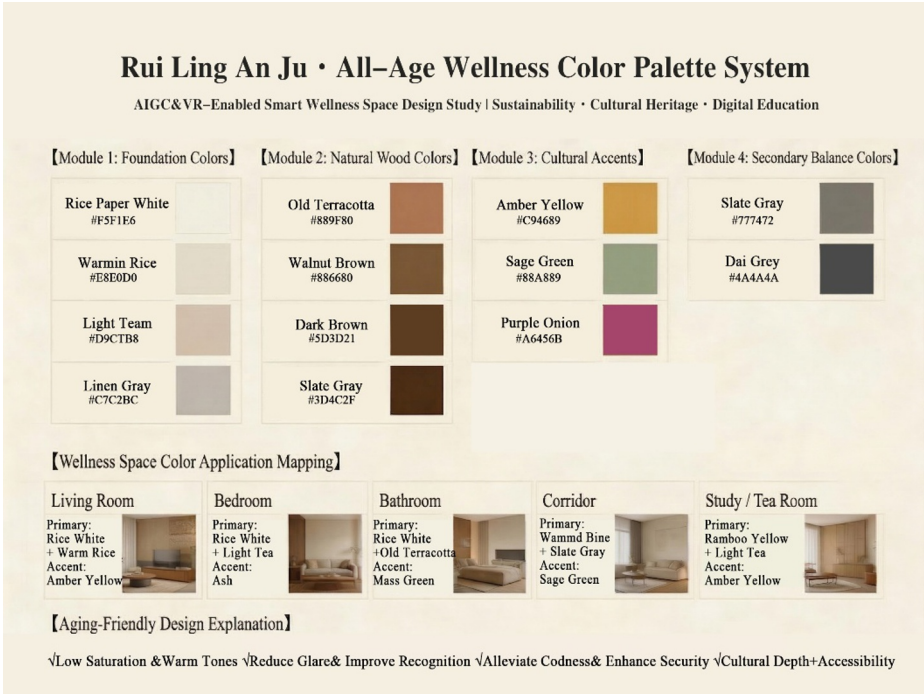


Fig. 1. Rui Ling An Ju · All-Age Wellness Color Scheme System

3.3 A Spatial Analysis of Digital Education Prototypes

Design is not just design; it should also serve as a teaching tool. This is another dimension of the "Rui Ling An Ju" concept.

3.3.1 Standardized Design Node Library.

Converting general age-friendly design standards into visual parametric models to create "educational learning points": wheelchair accessibility parameters (clear door width ≥ 900 mm, turning radius ≥ 1,500 mm), safety height parameters (emergency call buttons installed at dual heights of 100 mm and 600 mm above the floor), and handrail height parameters (based on ergonomic principles at 850 mm)—every figure is backed by verifiable data.

3.3.2 Transparency in Design Decisions.

The use of 3000K warm lighting in the space is not merely for visual comfort, but rather a finely tuned adjustment based on research into changes in the circadian rhythms of the elderly. Meanwhile, the open design of the sink area elevates accessibility from a basic compliance requirement to a proactive consideration of the user's dignity—it allows an elderly person in a wheelchair to approach the mirror and groom themselves just like anyone else. This preservation of the possibility of "eye-level interaction"

transcends mere functional accessibility and embodies an ethic of inclusivity deeply embedded in the details of the space. By grounding every key decision in its "physiological-psychological-ethical" triple foundation, the design proposal itself ceases to be merely a set of technical drawings and instead becomes a teaching case that can be repeatedly dissected, scrutinized, and debated. We hope to use this approach to guide students in developing a mindset of "evidence-based design"—not merely following formal trends or applying dogmatic standards, but learning to question the legitimacy of every design decision and to find the most delicate balance between physiological scale, psychological perception, and ethical boundaries.

4 Design Validation and Educational Applications Driven by AIGC and VR

The design itself is just the starting point. How can we prove that this design is truly effective? How can we ensure it can be experienced and optimized before it is built? This requires the use of technical methods for validation.

4.1 Development of the "Rui Ling An Ju" Prototype Model

First, through a systematic review of the literature and field research, we identified the core functional modules that wellness and care spaces should incorporate, drawing from existing theories and completed projects. Building on this foundation and guided by the "full life cycle" philosophy, we used BIM software to construct the basic three-dimensional spatial framework for "Rui Ling An Ju". Concurrently, we transformed the passive design strategies mentioned earlier—such as natural ventilation pathways and daylighting optimization mechanisms—into quantifiable geometric parameters, anchoring them within the spatial framework. This embedded a sustainable underlying logic throughout the entire design scheme.

4.2 AIGC-Assisted Solution Generation and Cultural Optimization

Building upon the base model, we aim to explore the validation support it can provide for design decisions—by inputting regional cultural keywords and using plugins such as ControlNet to impose precise constraints on spatial structures, the system can rapidly generate multiple interior design schemes that meet specific cultural requirements, enabling designers to confidently address diverse aesthetic preferences. At the same time, integrating local meteorological data (EPW files) into AI-assisted climate analysis tools can generate annual solar radiation heat maps and energy consumption simulation data. This allows for the validation of passive design strategies under actual climatic conditions and facilitates the optimization of window treatment strategies, thereby achieving the optimal balance between natural lighting and thermal comfort across different seasons. (as Figure. 2 and Figure. 3)

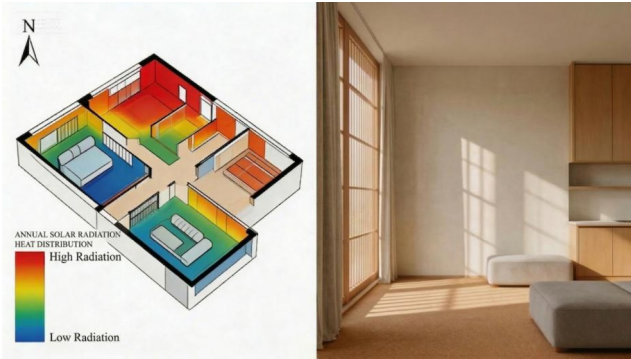
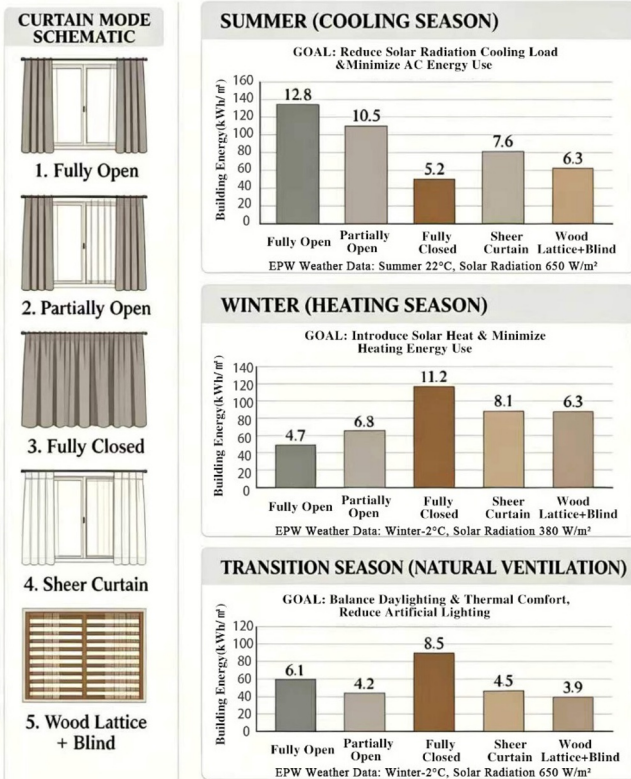


Fig. 2. Annual Sunlight Heat Map + Indoor Light and Shadow Comparison

Comparative Simulation of Energy Consumption for Smart Healthcare Spaces and Curtain Strategies

Passive Building Environment Optimization Analysis



CONCLUSION: Dynamic curtain strategies reduce energy reliance by 15%-30% | Passive design priority: Optimize orgating responses → Reduce balance on artificial lighting & AC | Thermal Parameters: $U=0.6 \text{ W/(m}^2 \text{ K)}$, $SC<0.3$

Fig. 3. Comparison Chart of Energy Consumption Simulations for Different Curtain Strategies

Building on this foundation, we leverage AI's style transfer capabilities to systematically optimize the color scheme of the space's predefined "warm-toned healing environment"—This process is not merely a matter of visual enhancement but is instead grounded in the physiological characteristics of the elderly, such as lens yellowing and reduced sensitivity to short-wavelength light. Through iterative algorithmic refinement, we seek the subtle balance within color combinations that most effectively evokes a sense of calm while ensuring visual comfort. In this way, we achieve a careful translation from a functional model to a cultural aesthetic. Simultaneously, we input the basic spatial model into an AI system, using cultural tags such as "New Chinese Style" and "Song Dynasty Aesthetics" as guides to generate multiple sets of adaptable soft furnishing schemes. (as Figure. 4)



Fig. 4. Close-up of the Cultural Display

4.3 Setting Up a VR Immersive Validation Environment

This study utilized the Unreal Engine 5 platform to build an interactive VR validation system, aiming to establish a perceptible pathway for transitioning from a "younger perspective" to an "aged perspective" in this context. Specifically, we pre-set a "simulated aging viewpoint" within the VR environment, locking the virtual camera height to the typical eye level of a wheelchair user (1,350 mm), and applied a visual blurring filter to simulate the visual impairment caused by common age-related eye conditions such as cataracts. This allows designers and evaluators to directly perceive, from a first-person perspective, how the space might appear during actual use[9].

4.4 Multi-Dimensional Evaluation System

Conduct a quantitative analysis of the design's natural ventilation rate and daylighting factor using specialized energy efficiency software to validate the sustainability of the

passive design. Invite wellness experts and senior volunteers to participate in an immersive VR experience, and use questionnaire surveys to assess the psychological sense of security and ease of use within the space. Preserve this design as a digital asset for use in university design courses, and evaluate the model's educational effectiveness in bridging students' "empathy gap regarding age-friendly design" through pre- and post-test comparisons.

5 Being Seen and Being Felt: An Evaluation of VR Experiences among Older Adults and Students

Through small-scale VR immersion testing, this study invited 10 elderly participants and 15 design students to take part in the experience, thereby preliminarily validating the effectiveness of the approach. Test data shows that elderly participants rated the visual comfort of the "warm-toned therapeutic space" significantly higher than the control group. More importantly, 85% of participants felt that the "Ziwan Study" spatial design evoked an emotional resonance with traditional lifestyles. Meanwhile, after completing self-directed learning through the "interactive teaching stations", the students who participated in the test saw a 40% increase in their accuracy rate regarding the principles of passive design. Students generally reported that the "simulation of viewing height" in the VR environment—a cognitive approach based on bodily perception—effectively bridged the "empathy gap regarding aging" that is difficult to overcome in traditional teaching.

Building on the aforementioned work, we will systematically package the digital assets that have undergone AIGC validation and VR testing, transforming them into knowledge resources suitable for educational use. Specifically, we will develop online course modules and record a series of video lessons titled "Appreciation of Smart Wellness Design", which will include VR navigation paths and expert narration. Additionally, we will create an interactive e-book that embeds VR scenes directly into the web interface. Students can click on hotspots while navigating the space to view text and image annotations regarding "transparency in design decision-making". This approach allows students not only to view the design outcomes but also to understand the rationale behind each design choice, as well as the sustainability, cultural, and educational values these decisions embody. Through the approaches outlined above, we aim to bridge the final gap between "design practice" and "design education", achieving a comprehensive transition from "design" to "teaching materials". This process also allows the tacit knowledge embedded in the design process to be consolidated, transmitted, and repeatedly applied, thereby providing a reference framework for the knowledge transfer in future projects of a similar nature[1].

6 Conclusion

In this study, based on the "Rui Ling An Ju" design proposal, we sought to explore the potential roles that AIGC and VR might play in the design of smart wellness spaces.

We integrated issues that were previously scattered across different fields—sustainability, culture, and education—into a cohesive whole. The results demonstrate that this "source integration + technical validation" approach endows the space with three key attributes: environmental friendliness, cultural identity, and educational exemplarity. First, it ensures that sustainability, culture, and education are embedded as the foundational logic of the space from the outset, rather than serving merely as afterthoughts. Second, once the AIGC-assisted generation and VR-based immersive validation form a closed-loop system, design decisions are no longer reliant solely on experience and intuition. Instead, they are supported by data for retrospective review and simulations for early error detection. Third, by packaging the entire design process into interactive digital resources, it transforms a one-time practice into a teaching case that can be repeatedly referenced and discussed.

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