12. Boundary Objects for Longevity Services: the Intersection of Tactility, Tech, and Trust

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INTRODUCTION

Demographic shifts (Coughlin, 2014; WHO, 2022), techno-economic advancements, progressive healthcare systems, the rise of AgeTech cities (Etkin, 2021), and evolving policies and social structures have contributed to increased lifespans and the desire for a robust health span in later years (Carstensen, 2009; Coughlin, 2017; Scott, 2024). Quality of life is intrinsically linked to strategic financial planning, yet the traditional life stages of learning, earning, and retiring are becoming obsolete amidst these complex systemic transformations (Golden, 2022). The multistage approach and mindset represent a new paradigm in the era of longevity. For example, Gratton and Scott (2017) define an asset as something that yields benefits over time. In this new paradigm, individuals consider not only tangible assets such as money, pensions, and homes but also intangible assets such as emotional support and social connections, productive assets such as reputation and knowledge, vitality assets including health and balanced living, and transformational assets such as diverse networks and self-knowledge.

In response to the shift toward a multistage life paradigm, which necessitates reevaluating diverse cultures, environments, organizations, and social infrastructures (Irving, 2014), we have shifted our focus from traditional financial planning to a broader approach termed Design for Longevity (D4L). D4L transcends mere monetary considerations, encompassing broader life themes: family, mobility, community engagement, risk assessment, investment strategy, trust-building, communication, and future planning (Kolluri, 2024). The concept of D4L aims to equip individuals with holistic preparation for their later years (Lee et al., 2022; Lee et al., 2023a). The integration of the D4L concept into services and systems can add value across various industries. For example, D4L in product design focuses on product lifecycle

(Carlsson et al., 2021); in sustainability, it promotes circular economics (Ellen MacArthur Foundation, 2020; Ellen MacArthur Foundation & IDEO, 2019); and in finance, it centers on longevity planning (Coughlin, 2017; Gratton & Scott, 2017), overlapping with life-centered design (Lutz, 2022).

Boundary Objects and Longevity Planning Blocks

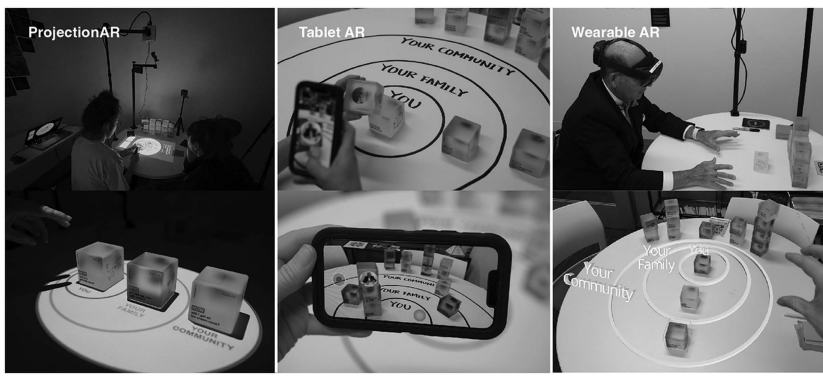
In 2023, MIT AgeLab introduced Longevity Planning Blocks (LPBs) as facilitation tools (Lee et al., 2023b) for financial advisors or longevity coaches to better understand client needs and enhance their longevity literacy. LPBs are a set of 12 tangible cubes made of translucent acrylic, each displaying a question relevant to longevity planning, accompanied by a matching icon and photo. The creation of LPBs was informed by the 8,000-day framework (Coughlin, 2019), representing roughly 22 years, the span of a traditional retirement beginning at age 65. This framework segments retirement into four distinct stages: managing ambiguity, making big decisions, managing complexity, and living solo. Each phase contains a unique set of challenges and opportunities that retirement causes, and it is these nuances and individual needs that the LPBs are designed to address, incorporating icons, photos, and eight thought-provoking questions designed to prompt self-reflection on important aspects of longevity planning, including considerations such as: "Who will care for you?", "What will your Tuesdays look like?", and "How will you prepare for retirement?" (Lee et al., 2023c).

In this study, we considered the 12 LPBs as boundary objects in the longevity service experiment. Boundary objects serve as a "medium of translation", playing a crucial role in fostering and preserving cohesion among individuals' distinct perceptions of longevity planning. The concepts of tangible/design artifacts and boundary objects assist in understanding LPBs as tools that facilitate individuals in expressing their longevity needs in the context of various social processes, identities, and status. Boundary objects have also been reexamined in contexts such as teaching and learning within relationships, particularly focusing on the learning dynamics between customers and consultants (Trompette & Vinck, 2009).

Immersive Technologies: Projection, Tablet, and Wearable AR

The advent of the fourth Industrial Revolution has fused the realms of the physical, digital, and biological, leading to increasingly sophisticated financial planning clients. These clients seek not only new knowledge but also customized products and comprehensive services. In light of this, our study investigates various multisensory and interactive methods to enhance longevity services, particularly for individuals with limited or no financial literacy.

We developed and tested three distinct longevity coaching experiences utilizing LPBs to experiment with three types of augmented reality (AR) formats, which integrate digital information within the physical environment (Figure 12.1). Each experience was crafted to discern the specific longevity-related needs and challenges of the clients and to foster a trusting relationship with a longevity coach. As this preliminary study represents an initial two-month research endeavor, it focuses on the early stages of the research and prototyping process.



Note: Participants place one LPB in each circle to symbolize themselves, their family, and their community, separately, by applying three distinct immersive technologies: projection, tablet, and wearable AR, arranged from left to right.
Source: Author's own.

Figure 12.1 Prototype of a longevity service using immersive technologies with LPBs

Boundary Objects through Tactility Engagement

In a world increasingly mediated by digital interfaces, which often lack the depth of tactile feedback—such as texture, weight, smoothness, and the dynamics of three-dimensional forms—the use of LPBs as boundary objects can allow individuals to tangibly navigate the intricate and sometimes overwhelming terrain of longevity planning, heightening their sense of agency. In this preliminary experiment, the author observed that the tactility of the boundary objects can better engage individuals in a comprehensive physical and mental experience. Nonetheless, using boundary objects in this tactile

engagement exposes individuals to the inherent vulnerabilities of personal and sensitive financial discussions. Additionally, this research investigates how combining boundary objects with three types of AR technologies not only emphasizes the tangible benefits of these boundary objects (LPBs) but also enhances the level of immersion, thereby creating a more meaningful, enduring educational impact for lasting understanding of longevity planning.

LITERATURE REVIEW

The Notions of Boundary Objects

The idea of boundary objects first introduced by sociologists Star and Griesemer (1989) refers to objects that can have varying significance across diverse social contexts, yet maintain a structure sufficiently universal to be recognized by various communities (Johnson & Anderson, 2020). Boundary objects can be applied as a means for collective learning through a process of reification. For instance, recognizing maps as boundary objects uncovers a collective process of sense-making and highlights the importance of cultivating creative skills that empower interdisciplinary communities of practice to become the norm. Additionally, maps as boundary objects mediate various types of participation and foster collective identities, guiding different communities toward a common orientation and alignment with other processes (Wenger, 2010).

Decomposing the term "boundary objects", we examine two words. The word "boundary" invokes the idea of periphery, edge, or margin, but we refer to the concept of shared space. The word "object" can be defined by how people/other objects/programs interact with and respond to it. Essentially, an object is shaped by these actions, behavior, or interactions, rather than by pre-existing materiality or prefabricated things (Star, 2010). Wenger (2010) described the notion of boundary objects across four distinct dimensions, encompassing: (1) abstraction, which facilitates dialogue across different realms; (2) multi-tasking, allowing for various possible activities or practices; (3) modularity, where different object components can facilitate dialogue among key actors; and (4) standardization, which makes the information about the object comprehensible. A broader interpretation of the boundary object encompasses roles of diverse artifacts, including materialized representations (e.g., LPBs, maps), classifications, directories, and standardized methods (Trompette & Vinck, 2009).

For analytic distinction purposes, boundary objects are categorized into four types: repository, ideal types, coincident boundaries, and standardized forms (Star & Griesemer, 1989). A repository type presents heterogeneous collections managed in a modular fashion. For example, a library can be considered as a set of organized and indexed objects structured in a standardized fashion.

An ideal type is a boundary object like a diagram or map, which is abstracted from the details of things to maintain its vagueness. Coincident boundaries refer to common objects with the same shared boundaries but different internal contents. Lastly, standardized forms indicate boundary objects devised as methods of common communication or things across dispersed communities to generate different interpretations. In this study, LPBs are identified as boundary objects within the standardized forms category. Their structure is consistent with that of tangible design artifacts, yet LPBs enable diverse interpretations influenced by individuals' demographics, longevity, literacy, culture, and other socioeconomic factors.

The design represents the continual evolution of its object. For example, the network of heterogeneous elements built or imported during the design process serves to reveal and enhance the characteristics and attributes of the object being designed (Binder et al., 2012). Simultaneously, the design process involves socio-material elements that may provoke various concerns and tensions, such as ill-structured versus well-structured or standardized versus wild, where boundary objects can be utilized as a strategy to address and resolve these issues (Star, 2010). Occasionally, the effectiveness of boundary objects might be compromised due to their inability to facilitate the creation of common ground, which is crucial for invoking the necessary aspects of contextual information (Bechky, 2003). Star highlighted that the critical aspect of a boundary object is the characteristic of interpretive flexibility. For example, the "same" map can contain different meanings, depending on how the object is applied and interpreted in what context. A map is used to show the way to a parking lot, a path to the campground, or a route for cycling.

Boundary objects represent a form of structure that enables collaboration across diverse groups, from individuals to communities, without requiring consensus. For instance, Verganti (2009) proposed the Design-Driven Innovation framework, which emphasizes the role of the "Interpreter" as a conduit between the "Firm" and the "User". This role serves as a form of structure for facilitating knowledge exchange, taking into account sociocultural models, meanings, and product languages. Its function mirrors that of boundary objects in promoting shared understanding. Beyond the initial concept of boundary objects, Bowker and Star (2000) extended their discussion to encompass multiple boundary objects and systems of boundary objects, ultimately expanding the scope to include boundary infrastructures (Star, 2010).

The Boundary of Immersive Technologies

Since Milgram and Kishino proposed the concept of the virtuality continuum in 1994, numerous scholars and industry professionals have contributed to defining the broad spectrum of "reality" experiences enabled by technology.

This continuum serves as a theoretical framework to categorize environments from fully real to fully virtual. At the heart of this spectrum lies mixed reality (MR), characterized by environments where real-world and virtual elements coexist within a single field of perception, engaging multiple senses (Skarbez et al., 2021). In this study, we focused on three specific augmented reality (AR) technologies within the MR domain: projection AR (Ciampa, 2021), tablet AR (utilizing a smartphone), and wearable AR (employing Microsoft HoloLens 2). A projection AR, tablet AR, and wearable AR are situated on the Milgram and Kishino continuum, and on an immersion scale ranging from low to high. However, for the research aim, we defined immersion in terms of dimensionality: projection AR presents as fixed and two-dimensional, tablet AR as portable and three-dimensional, and wearable AR as an interactive, three-dimensional digital overlay within a real-world context.

Projection AR utilizes light projection technology to enhance real-world surfaces, objects, and environments with digital imagery. Projectors alongside various sensors cast overlays that can change the appearance and functionality of physical space. This form of AR is particularly effective in industrial settings such as factories, where it provides workers with visual step-by-step instructions for training and assembly tasks (Ciampa, 2022). Beyond the industrial realm, projection AR is also embraced in the arts. Through the combination of projection mapping software and responsive sensors, it can transform environments into immersive and enchanting experiences.

Tablet AR, often employed through mobile phones, leverages video passthrough technology to superimpose digital content onto the real-world display captured by the device's camera. Since the unprecedented success of Pokémon Go in 2016, tablet or mobile AR has surged in popularity, operating primarily in three ways: (1) marker-based, where AR is activated by visual cues akin to scanning a QR code; (2) location-based, utilizing the device's GPS to trigger AR content; and (3) through superimposition, the most common method, where the device's camera recognizes and maps spatial planes to anchor virtual objects on precise surfaces, including the user's face. Tablet AR has found applications across a variety of consumer electronics. In entertainment, it is widely recognized for social media face filters, and it has also enhanced art exhibitions, such as "The Pursuit of Happiness". For personal shopping, apps such as IKEA Place allow users to visualize how furniture would look and fit in their homes, while Warby Parker offers a virtual try-on experience for eyeglasses. In the educational domain, applications such as Kinfolk bring to life AR monuments celebrating lesser-known American heroes for children.

Wearable AR, utilizing see-through displays akin to transparent glass, seamlessly integrates digital elements with the physical world. Following the notable setback of Google Glass in 2014, the journey toward widespread adoption

of wearable AR has seen its share of challenges: Magic Leap's significant stumble after a nine-year development cycle (Brustein & King, 2020); Focals by North, marketed as a chic "smartwatch for your face", only to be acquired by Google (Carman, 2019); Bose's venture into AR audio glasses, which was discontinued a year post-launch (Carman, 2020); and Snap Spectacles (Snap Inc., 2024), now primarily targeting content creators. Even with its application in sectors such as security, industry, and healthcare, the discontinuation of Microsoft's HoloLens 3 development underscores the hurdles in balancing cost, utility, functionality, aesthetics, and privacy concerns for consumer acceptance of emergent technologies (Sodhi, 2023). Nevertheless, the anticipated launch of Apple's Vision Pro in the spring of 2024 presents a promising horizon for AR accessibility. This juncture marks an opportune moment to explore and prototype the diverse experiences this immersive technology can offer.

The Boundary of Financial Services and Augmented Reality

Our investigation indicates that while there are intriguing applications of immersive technology in financial services, many have not reached full-scale implementation. For instance, the collaboration between Citi and 8ninths in 2016 resulted in the conceptual Holographic Workstation using the Microsoft HoloLens (Finextra, 2016). This prototype was designed to enable traders to interact with and comprehend financial data in a three-dimensional space. Additionally, MasterCard had plans to debut a tablet-based AR app in 2020, designed to showcase their Priceless credit card rewards program through photorealistic visuals within a 360-degree virtual environment (White, 2020). However, there appears to be no launch of such an application.

LONGEVITY SERVICE EXPERIMENT

Overview

The study examined the impact of different media (projection, tablet, and wearable AR) on a longevity service. The objectives of the experiment were twofold: (1) to curate a longevity service experience that would uncover the aspirations and challenges of the participants, and (2) to foster a foundation of trust and transparency between the facilitators and participants. Nine individuals affiliated with academia, aged between 35 and 45 and comprising six women and three men, were recruited through personal networks to participate in a 30-minute one-on-one longevity service session, which included a facilitator, the LPBs, and a single AR technology. The study concluded with a 10-minute debriefing session where participants shared their thoughts and impressions.

Pilot testing took place in a 300-square-foot laboratory, tailored with adjustable lighting to suit the AR technologies. The sessions were recorded using a 360-degree GoPro, a DSLR camera, and a laptop Zoom recording to capture participants' interactions and facilitate behavioral analysis.

Study Method

Scholars have evaluated various AR-based methods to assess their effectiveness, applicability, and analytical value in studies (Alves et al., 2021; Colley et al., 2020; Voit et al., 2019). However, their main research emphasis has been on these immersive technologies, excluding the consideration of boundary objects in the longevity planning context. In this study, the author utilized the think-aloud method (Someren et al., 1994) to gather and analyze verbal and behavioral data. This research methodology was selected to accommodate the personal, private, sensitive, complex, and experimental aspects of longevity planning. The approach was designed to authentically capture participants' feedback and stories across three different media.

The researcher took on the role of facilitator, guiding the participants through a structured 30-minute experiment outlined in four phases: setup, introduction, longevity service provision, and discussion. To maintain uniformity across sessions, the longevity service involved a single exercise that was replicated across all three media formats being tested. After familiarizing themselves with the content of the LPBs, participants were invited to prioritize these blocks by engaging in an exercise involving three concentric circles. This exercise is designed to help participants explore the connections between themselves, their extended families, and their communities, and to facilitate their understanding and discussion of longevity planning within a broader social system.

The Boundary of Longevity Service and Immersive Technologies

During group 1 longevity service, we utilized a KODAK Luma 350 Portable Smart Projector to project an animated Keynote presentation onto a round table in a lab space, thus creating a basic projection AR scenario. This setup transformed the table into what seemed to be a dynamic display, with visual elements progressing in response to the participants' actions. This projection served as a catalyst, guiding participants throughout the coaching session. The longevity coach was actively involved throughout, delivering content and leading the three concentric circles exercise.

In group 2, the facilitator utilized tablet AR, complemented by a laptop and a printed canvas as supplementary tools. The facilitator began with a concise presentation on longevity concepts using the laptop. Subsequently, participants

engaged with the AR-enhanced LPBs independently. The AR feature, powered by the marker-based AR platform Artivive, activated specific video overlays when the LPBs were viewed through the tablet. After acquainting themselves with the content, participants were prompted by the facilitator to organize the LPBs on the printed canvas according to their understanding.

For group 3, the longevity service was crafted around wearable AR, specifically using the Microsoft HoloLens 2. This allowed for a self-directed session with the LPBs. The facilitator initially assisted participants in setting up the headsets, then exited the room, leaving participants to explore the educational content independently. Interacting through gestures, participants navigated the content and performed the concentric circle exercise with the LPBs.

RESULTS

The Boundary of Exploration

From the experiment result, group 1, devoid of tablets or wearable devices, engaged most directly with facilitators, suggesting a heightened potential for in-person trust-building due to increased rapport. The fact that there was less guidance from the facilitator in groups 2 and 3 afforded participants greater independence to delve into content and explore the exercise at their leisure. This approach could encourage participants to navigate their learning based on their needs, representing a departure from the traditional, unidirectional model of financial or longevity planning. Participants in group 2 enjoyed the freedom to peruse content in any sequence, fostering autonomy. For group 3, the wearable AR altered their surroundings, offering a sense of privacy and control even before using LPBs. Conversely, the continuous guidance by facilitators in group 1 could potentially constrain participant autonomy and privacy due to persistent interaction.

The Boundary of Scaling

The experiences in groups 1 and 2 were more practical and, by extension, more scalable. The ease with which sessions can be facilitated is critical for viability. This necessitates the reliability of the technology and equipment used, as evidenced by a situation where facilitators encountered difficulties logging into the HoloLens, resulting in a rescheduled session. Despite initial apprehension toward novel technologies, these tools recontextualized the LPBs, transforming them into innovative, tactile, and creative instruments that enriched the immersive quality of the coaching experience.

In evaluating the values and constraints of employing three diverse immersive technologies, considerations around accessibility, intimacy, cost, device

portability, and user familiarity are crucial for future research. These factors are intricately linked to the effectiveness, usability, and user experience crucial for delivering personalized, human-centric longevity services, reflecting the educational value and longevity literacy we discerned throughout the experiment (Table 12.1).

Table 12.1 Comparison of boundary objects paired with three distinct immersive technologies

Group	1. LPBs + Projection AR	2. LPBs + Tablet AR	3. LPBs + Wearable AR
Tools	KODAK Luma 350 Projector and Keynote	iPhone 12 Pro and Artivive app	Microsoft HoloLens 2 and Dynamics 365 Guides
Value	Projection AR effortlessly immerses participants, building an intimate experience with minimal effort required from them, thereby enhancing the engagement between facilitator and participant.	Tablet AR stands out as the user-friendly and accessible form of AR, offering an easy setup for facilitators. This ease of use grants participants the flexibility to initiate and direct the delivery of content.	Wearable AR can facilitate a collaborative experience that can be conducted remotely. The headset offers a private space for introspection, crafting an exclusive and thrilling experience for both participants and facilitators.
Constraints	Projection AR is suited for a fixed location and is not portable, limiting its application to specific, stationary settings. Furthermore, the deployment of this technology in longevity services can inadvertently establish a subtle power imbalance between facilitators and participants.	Tablet AR, such as Artivive app, offers a constrained range of virtual functions and interactive capabilities. Furthermore, facilitators face a significant time investment in developing augmented content for the LPBs prior to their deployment.	Wearable AR presents a learning curve as participants adjust to new technologies, which can affect their comfort levels. The accessibility of wearable AR is currently restricted by the costs associated with the hardware and necessary software licenses. Additionally, the experience can be complicated for both facilitators and participants, as it involves users in novel gestures and interfaces, as well as addressing any technical issues that may arise.

Group	1. LPBs + Projection AR	2. LPBs + Tablet AR	3. LPBs + Wearable AR
Learnings	Projection AR is an engaging and memorable tool that fosters opportunities for participants to build trust with longevity coaches.	Mobile AR offers accessibility, affordability, and the ease of seamlessly integrating and scaling alongside the LPBs.	Wearable AR provides enhanced privacy, a sense of safety, and personal space, making it conducive to reflecting on sensitive subjects.

Source: Author's own.

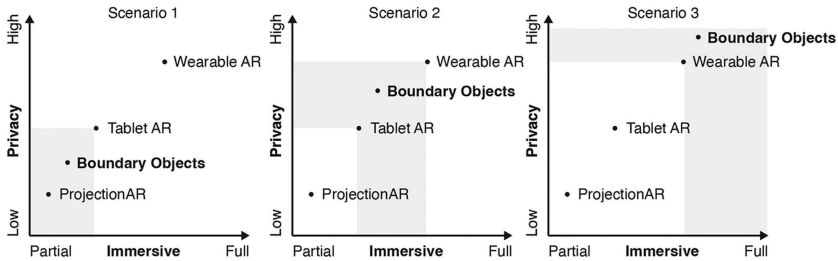
Besides exploring the interaction of LPBs with three unique immersive technologies, future research could examine the relationship between LPBs and the three AR technologies in relation to the four categories of boundary objects identified by Star and Griesemer (1989): repositories, ideal types, coincident boundaries, and standard forms. This analysis could also extend to systems of boundary objects and boundary infrastructures for longevity services, as conceptualized by Bowker and Star (2000).

DISCUSSION

The Scenarios of Longevity Services

In our exploration of three distinct immersive technologies with nine participants for delivering longevity services, we were intrigued by the role of boundary objects (e.g., LPBs) and sought ways to enhance their utility by integrating them with other media forms to craft a fully immersive and highly private longevity planning experience. Figure 12.2 presents three potential scenarios to facilitate our discussion on how AR influences participants' experiences with LPBs, considering the dimensions of privacy (y-axis) and immersion (x-axis). In our study, we interpret privacy as the degree to which others can observe your content, including screen interfaces, decision-making processes, and similar aspects.

Scenario 1 aims to bring the essence of our experiment to life. Utilizing 12 boundary objects and a tabletop projector, we crafted an engaging and interactive setting that allowed participants to delve into the topic of longevity planning alongside facilitators. Incorporating boundary objects into the process introduces an element of serious play into the discussions, though it may compromise participant privacy to some extent. Given this scenario's reliance on



Source: Author's own.

Figure 12.2 The three scenarios of the position of boundary objects

a facilitator, the quality of the experience can vary significantly, based on the facilitator's experience, expertise, and interpersonal skills.

Scenario 2 aims to investigate and prototype the capabilities of boundary objects to determine their potential for repurposing and transformation, focusing on medium-level immersion and privacy. An illustrative approach involves integrating tablet AR or extended reality (XR) with boundary objects. Rather than viewing boundary objects as distinct toolsets, the idea is to reimagine them as components of immersive media subsystems. This integration would seamlessly connect physical and digital service experiences, enabling participants or clients to scan QR codes on displayed products. By doing so, they can access audio or textual explanations, thereby enhancing their experience with a virtual longevity learning journey.

Scenario 3 explores the potential of boundary objects, when integrated with wearable AR, to enhance their value by creating highly immersive experiences that also prioritize privacy. This scenario posits that combining boundary objects with such technologies could offer the greatest benefits to users or participants. However, there are several challenges to address, including technical hurdles (e.g., learning time and adjustment cost), the need to prove the technology's feasibility, the viability of the business model, and the desirability by users. Successfully blending physical and digital environments, in a high-end context using cutting-edge technology, could be a fruitful way to entice potential clients.

The Engagement of Longevity Services

Using the think-aloud method with nine participants engaged with the longevity service for 30 minutes, we analyzed and synthesized the experiment to demonstrate that boundary objects not only facilitate the articulation of

complex and abstract longevity concepts but also enhance the expression of participants' narratives through more dynamic body language. For example, participants utilized the 12 LPBs in various configurations and layouts, augmenting them with Post-it notes to "show" their opinions and concerns. Consequently, employing boundary objects within a longevity service transforms the role of longevity coaches and facilitators from passive consultants engaged in one-way transactional communication to active mentors fostering a dynamic conversational environment. This shift is further enhanced by the integration of AR technologies, which empower more interactive and engaging dialogue.

Moreover, each AR technology uniquely augments the educational experience of participants, highlighting diverse methods to make longevity service more comprehensible and transparent to participants. For instance, longevity services have the opportunity to evolve from mere transactional, goal-focused interactions—like retirement planning—to more engaging, conversation-led, experience-centric journeys akin to longevity design.

CONCLUSION

In an increasingly aging society where longevity is on the rise, the quality of extended life is not assured. Longevity wellbeing is pivotal for aging with dignity and health, which necessitates a shift from mere financial planning to comprehensive longevity planning. This shift has led to the development of 12 Longevity Planning Blocks (LPBs), designed as facilitation tools to understand individual longevity needs more deeply. LPBs serve as boundary objects within a longevity service, employing projection, tablet, and wearable augmented reality (AR) technologies. They convey diverse meanings to individuals across various social contexts and demographics. The knowledge, personal capabilities, and social competencies of longevity coaches could revolutionize participants' engagement in financial advising.

The study also revealed that immersive technologies can foster a private and autonomous environment, conducive to personal introspection and decision-making, and beneficial for discussing sensitive and intricate topics related to longevity coaching and financial planning. Observations from the experiment indicate that diverse immersive technological environments have the potential to enhance trust and privacy to varying degrees. Such an environment, centered on boundary objects, enhances the service experience. Notably, wearable AR shows promising commercial prospects for delivering engaging and immersive longevity coaching services. Consistently across all groups, participants were seen naturally handling and manipulating the LPBs, using them as tools for articulation and idea-sharing. The value of boundary objects—engaging in serious play—was evident in the participants' interactions. Regardless

of the technological medium used, LPBs proved effective in helping participants articulate complex longevity needs and longevity concepts, affirming previous findings that tangible, thought-provoking objects can facilitate deep personal reflection and dialogue.

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