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Article

Gamification and Escape Rooms for the Validation of Assistive Technologies: A Participatory Experience with Older Adults in Cross-Border Rural Settings

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Abstract: This study evaluates escape room gamification as a participatory methodology for validating assistive technologies with older adults in cross-border rural areas through the VIVEMAIS INTERREG project. Deployed via the "Diversiverso" mobile living lab across eight Spain-Portugal municipalities (April–July 2025), the intervention engaged 331 participants (mean age 78.4 years) testing 18 assistive devices through challenge-based interactions. A mixed-methods approach combined quantitative surveys (n = 331; TAM attitudes, technology recall) with caregiver interviews (n = 11). Complementary triangulation identified three dimensions: technological appropriation, pedagogical function, and validation potential. Escape rooms fostered initial engagement but modest adoption intent (34% willing to take devices home), moderated by cognitive impairment and rural connectivity barriers. The study introduces "pedagogical realism", a dual effect where gamified interaction simultaneously generates enthusiasm and critical awareness of practical limitations. This distinguishes escape rooms from purely motivational approaches, positioning them as diagnostic tools bridging design, evaluation, and implementation phases. Discussion demonstrates that Technology Acceptance Model (TAM) limitations are addressed by Senior TAM (STAM), while supervised exergame meta-analyses confirm mediation effects in cognitive impairment. Caregivers emerge as essential intermediaries, particularly in rural contexts. Conclusions recommend integrating escape rooms within comprehensive strategies incorporating sustained mediation and transfer activities. The approach reveals a critical gap between experiential engagement and sustained adoption, informing user-centred innovation ecosystems for aging-in-place technologies.

Keywords: Escape Room; Gamification; Assistive Technology; Older Adults; Rural Aging; Pedagogical Realism; Technology Adoption

1. Introduction

This paper presents part of the findings from a field study conducted within the framework of the project "VIVEMAIS: Cross-border and transdisciplinary community for the design, adoption, and use of innovative assistive

technologies", funded by the INTERREG Spain–Portugal (POCTEP) 2021–2027 programme. The ultimate aim of VIVEMAIS is to introduce these technologies so that older adults can remain in their own homes without having to move to a care institution, thereby addressing several significant problems such as the demographic challenge, unwanted loneliness, and the simple fact of being able to stay at home even at a very advanced age.

The paper presents the results of applying participatory and gamified methodologies such as the escape room with the goal of identifying, co-creating, validating, and adapting assistive technologies within the context of the VIVEMAIS project.

The project was carried out in several cross-border areas between Portugal and Spain, where support solutions, designed primarily for older adults but also for individuals with physical or intellectual disabilities, were brought closer to users and implemented in a capsule we call "Diversiverso" and a mobile living lab, providing key and effective research infrastructures that engage diverse actors in an iterative, user-centred open innovation ecosystem and promote co-creation in real-life settings [1].

The project aims to test and improve assistive technologies in collaboration with older adults and/or individuals with disabilities, using service-learning approaches that support user-centred co-creation and evaluation of technology [2]. Integrating game-based dynamics such as escape room-style challenges introduces a motivational and experiential dimension that encourages active user participation and allows the usability and effectiveness of technological solutions to be assessed in simulated yet realistic contexts [3]. This gamified approach not only helps identify barriers to use but also fosters participants' appropriation of technology. FabLabs, in parallel, play a key role as spaces for digital fabrication and rapid prototyping, enabling the adaptation and customisation of assistive technologies based on the needs identified during testing, effectively functioning as interpreters of the issues raised in the interviews. This synergy between service-learning, gamification, and digital fabrication helps to generate more inclusive, sustainable, person-centred solutions.

The VIVEMAIS community is made up of individuals living in Castilla y León and northern Portugal. Above all, it comprises users of social services and their families and/or carers. Furthermore, it also includes the broader social fabric that supports them and with whom they share their daily lives, including service providers, local councils, primary healthcare centres, educational institutions and universities, companies developing or offering technological and/or care solutions, religious institutions, local action groups, and establishments open to the public (pharmacies, bars, grocery stores) [4]. Despite living in different countries, people in these areas face similar challenges, as they are rural areas with a low and highly dispersed population density, making access to all types of services extremely difficult. The population shows high levels of ageing and dependency, so assistive technologies could significantly improve their quality of life; however, due to the specific characteristics of this group, there is some reluctance to adopt such technologies [5]. An additional and highly relevant issue is limited Internet connectivity in the area, which must be considered when introducing any type of technology [6,7].

The tests were carried out in the "Diversiverso" capsule, a mobile unit designed to simulate a household environment where the assistive technologies under evaluation are installed with the aim of helping older adults to live independently for longer. The capsule was presented along a route comprising eight cross-border municipalities between Portugal and Spain, where the support solutions developed were tested and refined. This itinerary took place between April and July 2025 in eight stages: Toro (Zamora-Spain), Béjar (Salamanca-Spain), Fermoselle (Zamora-Spain), San Esteban de la Sierra (Salamanca-Spain), Ciudad Rodrigo (Salamanca-Spain), Alijó (Portugal), Freixó de Espada a Cinta (Portugal) and Benavente (Zamora-Spain).

The project comprises 3 distinct phases. In Phase 1 (design and planning), users' needs were identified through interviews and focus groups; the technologies to be tested (prototypes or existing solutions under development defined for the "Diversiverso" capsule) were selected; game-based challenges in an escape room format that integrated the functional use of these technologies were designed; and, finally, sessions were scheduled in the FabLab to customise and adapt the devices based on the feedback. In Phase 2, interaction sessions were conducted: using an escape room as a gamified test environment; carrying out structured observation of how the technology was used by the individuals who agreed to take part in the experience; and collecting qualitative and quantitative data through interviews and questionnaires. Phase 3 included the evaluation of all participants.

Unlike previous studies, this work does not use the escape room as a strictly educational or awareness-raising tool, but rather as a methodological instrument for technological validation focused on the experience of older users. The main contribution of this work is therefore to further develop the use of gamification through an escape room

as a participatory tool for validating assistive technologies with older adults, particularly in rural and cross-border contexts, by adapting a didactic-educational methodology and testing its effectiveness in other environments, such as the one presented here, where it is also implemented as an evaluation tool.

In short, the main contribution of this work lies in presenting the escape room methodology as a validation tool that employs Challenge-Based Learning (CBL) with older adults who, while engaging in an enjoyable game-based activity, help evaluate specific assistive technologies designed to improve quality of life for them and their peers.

2. Escape Room (Gamification), Assistive Technologies and Older Adults: State of the Art

Gamification is gaining wide acceptance, especially through one of its most familiar formats: the escape room. This is a game-based activity where participants collaboratively solve challenges in a themed, controlled environment that simulates real or fictional scenarios with the common goal of "escaping" or completing a mission within a limited time [8].

The escape room concept originated in the digital realm with the game "Behind Closed Doors", created by John Wilson in the 1980s, in which participants were required to engage with the situation, solve the proposed puzzles, and achieve success by making decisions. However, it was not until 2008 in Japan that the entrepreneur Takao Kato designed a room in which players were immersed in a story and had to solve various puzzles using clues they would find hidden in the same room. This series of challenges would lead them to the solution that would allow them to escape and complete the game. This would be the first live escape room, marking the start of what has since become the global escape room phenomenon.

From the world of video games and entrepreneurship, it then made the leap to the educational field, as it was considered an important resource for developing creativity and critical thinking in young children. In recent years, studies on the educational impact of escape rooms have multiplied, along with reviews analysing this research [9, 10]. Most suggest that escape rooms can be one of the range of teaching tools available to teachers in order to achieve the threefold goal of curriculum-reform initiatives, key competences, and 21st-century skills. This is one of the conclusions of a systematic review of studies on the use of escape rooms as an educational resource, which surveys up to seventy different cases [11]. Among these, those that focus on the educational process itself stand out, whether in primary, secondary or university classrooms, and particularly in contexts related to GBL or Game-Based Learning [12]. García Alonso et al. [13] present a solid theoretical framework on gamification in education, highlighting its positive impact on motivation, engagement, learning retention, and the development of transversal skills such as collaboration, critical thinking, and problem-solving. In this context, both face-to-face and digital educational escape room experiences are presented as versatile pedagogical tools that can adapt to various educational levels and disciplinary areas, offering particular potential for active and experiential learning. However, this expansion within educational contexts has pushed into the background its potential as a tool for evaluating experiences and barriers to use in other population groups.

VIVEMAIS aimed to adopt this methodology, previously applied mainly in entrepreneurial and educational settings, and to use it as a validation tool for assistive technologies, employing GBL with older adults who, while testing everyday prototypes and tools, validate or reject their implementation, acting as experts by virtue of their lived experience. However, although there are numerous studies on gamification and escape rooms [14–17], we find a gap when it comes to studying the escape room–older adults–assistive technologies intersection.

Among the literature consulted, three recent proposals stand out. In one of them, the escape room is used to promote the development of socio-emotional skills in response to social and communicative challenges among 7th- and 8th-grade primary school children, a context in which active and immersive methodologies, such as narrative gamification with role-playing games, offer an alternative for experiencing diverse situations from an emotional and participatory perspective [18].

A second work is framed as an educational experience and uses the escape room with older adults, specifically with Alzheimer's disease. In relation to the aforementioned study, it enabled the expression of ideas and emotions and the recall of memories through reminiscence, demonstrating that the escape room constitutes an innovative and viable educational resource for older adults with early-stage Alzheimer's disease, as it functions not only as a recreational activity but also as a means to stimulate cognitive and social functions, help slow deterioration, and enhance emotional well-being [19]. It is therefore clear that by activating emotions through this methodology, significant results can also be achieved when addressing any area related to the participation of older adults, including

those with severe mental health problems [20].

The last of these connects more directly with our analysis, namely the campaign "Escape Room Loneliness", led by Fundación La Caixa and launched in October 2024 [21], the result of more than 10 h of interviews with participants and several intensive sessions with all professionals involved in the Fundación's "*Siempre Acompañados*" programme, aimed at documenting the daily habits, emotions, and thoughts that overwhelm older adults when they experience unwanted loneliness. As a result of this process, they identified a recurring sentiment: the sensation of being trapped in a reality from which there seemed to be no way out, the starting point for what later became "Escape Room Loneliness", a wholly different escape room which, far from offering a recreational experience, served two purposes: to raise awareness of unwanted loneliness through a lived experience and, at the same time, to act as a metaphor for the feeling of emotional imprisonment in which the individuals they spoke to seemed to live. In this framework, they defined "Escape Room Loneliness" as an immersive, experiential journey that allows participants to put themselves in the shoes of an older person experiencing loneliness; a physical space where they can experience first-hand fear, frustration, and darkness, but also the hope that escape is possible.

These three works show that, above all, it is recreational and educational experiences that tend to accompany the gamification–escape room combination. This mainly refers to how it is implemented with groups made up of children and young people. Only La Caixa [21] seems to take a step forward, using this methodology to create an immersive, experiential activity that illustrates how older adults experience loneliness. In other words, it applies an emotional perspective to address deep experiences of suffering.

However, specific evidence linking escape rooms with technological validation in older adults remains limited. There are related initiatives in the form of escape games (particularly digital versions) specifically designed for older adults through user-centred design approaches. Doroudian et al. [22] demonstrate that narrative-based challenges and puzzles involving collaborative problem-solving can be both acceptable and enjoyable for this group. Test sessions make it possible to identify barriers to interaction, needs for support, and necessary adjustments to difficulty, using usability/playability evaluation methods that focus on the game itself rather than on other technological devices.

From this perspective, the gap in the literature involves not only the lack of studies on assistive technologies, but also the scarcity of research employing the escape room as an evaluation tool to examine how older adults' relationship with technology evolves. From an analytical perspective, this methodological shift makes it possible to operationalise technological openness not only as a declared attitude, but as a situated experience: voluntary participation, solving challenges with social support and guided contact with devices, together with observable and self-reported indicators (e.g., enjoyment, perceived ease and intention to use) [22]. The main contribution of this work lies in presenting the escape room methodology as a validation tool that employs CBL with older adults who, while engaging in an enjoyable game-based activity, help evaluate specific assistive technologies designed to improve quality of life for their peer group.

3. Methodology

The aim of this study is to assess the potential of the escape room as a participatory and gamified methodology for user-centred validation of assistive technologies within the framework of the VIVEMAIS project, implemented in the "Diversiverso" capsule in cross-border rural territories. Specifically, the study examines whether this dynamic, by proposing challenges and guided interaction with devices in a simulated domestic environment, facilitates participation and makes it possible to collect meaningful evidence on usability, acceptance, and the real difficulties of use among older adults and/or individuals with disabilities.

Our working hypothesis is that, by turning "openness to technology" into a situated experience, the escape room not only increases engagement and reduces initial resistance to technology, but also serves as an evaluative tool to identify barriers and facilitators of acceptance beyond self-reported attitudes. For this reason, the analysis aims to link participants' experience of the activity with indicators of interaction and acceptance (such as recall of the technologies, willingness to take them home, and attitudinal dimensions linked to TAM), integrating participants' direct perceptions with the mediated perspective of caregivers and professionals who accompany and support the everyday use of these solutions.

The methodology used is as follows: the general methodology, applied during the second phase of the VIVEMAIS project and focused on evaluation, and the specific methodology, linked to implementing the escape room in

the capsules, where the technology is tested with users.

3.1. General Methodology

The adopted approach uses a mixed, exploratory, and adaptive methodological design. It combines different techniques to capture both the direct perceptions of older adults and dependent individuals after they have taken part in the technology demonstration capsules (quantitative analysis), and the mediated perspectives of carers and professionals who accompany and support the everyday use of assistive technologies (qualitative analysis).

Integration is carried out using complementary triangulation, whereby the quantitative component provides an overview of patterns of technology acceptance and living conditions among older adults and dependent individuals in rural contexts, while the qualitative component offers a situated understanding of the underlying mechanisms (barriers, facilitators and living conditions), drawing on caregivers' accounts to explain these patterns.

The quantitative component consists of a face-to-face survey based on a structured questionnaire hosted in Qualtrics and administered by the survey team. Given the characteristics of the population (functional dependency and occasional memory difficulties), a format resembling a structured interview was adopted, incorporating brief reformulations and explanatory pauses to ensure understanding. The questionnaire included the following modules: (a) experience in the capsules and recall of technologies, (b) attitudes towards technology using an abbreviated TAM, (c) quality of life and capabilities using ICECAP-O, (d) health status using EQ-5D, and (e) sociodemographic variables.

Different elements of the evaluation were operationalised through quantitative analysis. First, recall of the technology shown in the capsules was used as an approximate indicator of its impact on the user. The second element, meanwhile, focused on usability or intention to use, measured through users' statements about whether they would take the technology home.

Semi-structured interviews were also conducted with carers and professionals directly involved in the daily lives of the older adult participants. The inclusion of the qualitative module responded to a finding observed during the implementation of the capsule: in many cases, carers demonstrated greater interest in and ability to interpret the technologies than the users themselves, highlighting their role as mediators between individuals and technology. Sampling was purposive and aimed at maximum variation, selecting diverse professional profiles to capture heterogeneity in care contexts and digital competences. In total, 11 complete and comparable interviews were conducted, with profiles covering roles in social work, social education, psychology, assistant roles, and sociocultural animation (**Table 1**).

Table 1. Qualitative profiles.

Interview Code	Professional Profile	Type of Population Served	Participation in Escape Room
CR_1	Psychologist and community facilitator	Individuals with disabilities and users of supported housing	No
FE_1	Social worker (vulnerable individuals)	Individuals in situations of social vulnerability	No
FE_2	Sociocultural facilitator in care home	Highly dependent institutionalised older individuals	No
SE_1	Social educator, cultural facilitator	Dependent individuals and the local community	Yes
BJ_1	Day centre assistant	Individuals with mental illness and disability	Yes
TR_1	Social worker, case and community service manager	Older and dependent individuals in their homes	Yes
BJ_2	Day centre assistant	Individuals with mental illness	Yes
Bn_1	Day centre assistant and technology trainer	Individuals with mental illness in the centre and in supervised housing	No
Bn_2	Activities assistant and new technologies teacher	Older adults (care home and day centre)	Yes
CP_1	Provincial project coordinator	Older adults and individuals with disabilities who still live in their own homes	Yes
al_1	Provincial social services coordinator	Older adults in contexts of vulnerability	No

Reflexive thematic analysis was applied for analysis of the interviews, developing interpretative categories on the impact of the escape room on technology acceptance contexts. To reduce interpretative bias and strengthen the consistency of the category system, two researchers from the team independently conducted double coding, followed by a joint session to compare discrepancies and agree on the operational definitions of the codes. In this case, based on the analysis of the experiences reported by the carers who attended the sessions and were able to observe the escape room, we explored the extent to which users benefited from it and their sense of enjoyment.

Integration of both components was carried out using complementary triangulation, aimed at strengthening the internal validity of the analysis and broadening the understanding of the phenomenon. In operational terms, the quantitative component made it possible to identify patterns of acceptance of and interaction with technology (e.g., recall of devices, willingness to take them home, and attitudes measured using TAM), while the qualitative component provided a situated, contextualised interpretation of the mechanisms underlying these patterns (barriers, facilitators, environmental conditions, and the mediating role of the caregiver/professional). Triangulation was therefore not conceived as verification by redundancy, but as a form of explanatory integration.

3.2. Specific Methodology

Escape room experiences demand special preparation, with the narrative or storyline requiring carefully crafted staging and a deliberately designed atmosphere, including lighting and music. All of this is essential for players to feel part of a unique experience and to feel immersed in the game [2,8]. On this basis, this work was organised in different stages:

I. Design of the experience around a challenge: definition and game mechanics. The aim in this case is to test assistive technologies in order to assess their ease of use, degree of acceptance, difficulties, etc.

II. Needs and design of the experience: in order for the escape adventure to work, in phase 2, as a hands-on experience in using assistive technologies, the needs of the target group were identified: how could this escape-room activity contribute to improving the use of the proposed products?
First, a sample of participants who took part in the capsules was selected, as summarised in the following **Table 2**:

Table 2. The sample.

Locality	Participants	Locality	Participants
Toro	44	Ciudad Rodrigo	76
Béjar	11	Freixo de Espada a Cinta	70
Fermoselle	20	Alijó	82
San Esteban de la Sierra	4	Benavente	44

The "Diversiverso" capsule was designed to simulate a home environment where the intended assistive technologies were arranged. The escape room challenges were distributed across all the rooms so that users could try out the technologies.
The spaces were adapted to accommodate individuals with reduced mobility and other types of visual, auditory, cognitive, and physical needs. The escape room challenges were adapted using clearer, more easily understandable language to meet users' needs (larger print, clearer and simpler clues, etc.).
Different challenges were designed to allow the technologies to be used independently, without requiring a logical sequence, so that multiple users could interact simultaneously without following a fixed path.

III. Validation. In the final stage, the various challenges designed to assess the technologies were developed (**Table 3**). The challenges were then selected according to the type of users and their cognitive capacities. In total, 9 challenges were implemented using 18 different types of technologies.

Table 3. Development of the escape room challenges applied in the capsules.

Challenge	Type of Challenge	Difficulty	Time Taken	Technologies Tested
Secret book of Les Misérables/English dictionary	Logic	Low	5 min	Firestick TV remote controls
	Development A card is provided bearing a sentence that refers to the book Les Misérables, with a key attached. The participant must search the nearest shelf for the book where one of the assistive technologies is hidden.			
Jars of condiments in the kitchen	Logic	Medium to high	10 min	Pill organisers Tablet Remote care kit
	Development A card is provided bearing a rhyming sentence that refers to the jars of condiments in the kitchen. In one of them, a second clue leads participants to the task involving a technology hidden in a basket of towels.			

Table 3. *Cont.*

Challenge	Type of Challenge	Difficulty	Time Taken	Technologies Tested
Suitcases and bags	Logic	Low	5 min	VR headset VR Banking Pill organisers Fall alert watch Tablet Booster cushion
	Development A card is provided bearing a sentence adapted to the audience, making it simpler or more detailed as needed, and referring to suitcases, trunks, or boxes containing blue and green T-shirts. Technologies are hidden inside them.			
Strap	Skill	Low	5 min	Robotic pet Exercise equipment
	Development A card with a key attached is placed near the technology to be tested. The clue refers to the pet or to the exercise equipment. The technology is unlocked by opening a strap lock.			
Clues in the fruit	Logic and skill	High	15 min	Food processor Adaptive cutlery set Various 3D-printed tools for assistance during meals, carrying objects, and related tasks.
	Development A card from a health organisation is provided, urging people to eat fruit. By going over to that piece of fruit, 3D-printed in the FabLab, the pieces of fruit are counted and a coloured lock is opened, unlocking the technology.			
The deck of cards	Logic and recall	Medium	10 min	Alexa Smartwatch
	Development A card is provided that refers to a deck of cards. Once the deck has been found, it has a key that opens a case with the technology inside.			
Search on the map	Logic and recall	Medium	10 min	HELPINDER
	Development A box is provided containing a world map, a jar of pens, one of which reveals invisible ink, and a picture frame with a photo of the corresponding locality. Ultraviolet light must be used to reveal a phrase hidden in the photo frame of the locality, where a reference to the box containing the world map has been written in invisible ink. Once the box is opened, the HELPINDER code is there inside.			
Kandinsky painting	Logic and recall	High	15 min	VR BANKING
	Development A Kandinsky painting made with vinyl is displayed in the mobile FabLab; when a printed clue is placed over the painting, a combination of colours appears that opens the locked VR headset.			
Syllable game	Logic, skill, and recall	Medium	30 min	VIVECONmigo
	Development A logic game produced in the mobile FabLab is provided. The game brings together the syllables of VIVECONmigo and refers to a padlock that opens a box, suitcase, or similar container where the technology is kept.			

4. Results

4.1. Impact on Users: Quantitative Analysis

Participation in the escape room amounted to 32.5% of the users who attended the capsules, i.e., approximately one third of the sample. Before analysing the effects of the activity, it was assessed whether there were any initial differences between participants and non-participants. For this purpose, sociodemographic and health variables (sex, age, and perceived health status) were compared. Neither the χ^2 tests nor the mean comparison tests yielded statistically significant differences ($p > 0.05$), indicating that the groups were comparable in their baseline characteristics. Only a slight over-representation of women and a somewhat lower mean age were observed among participants in the escape room, although these differences did not reach statistical significance.

One of the main indicators analysed was recall of the devices presented in the capsules. Among the most frequently remembered were the pedal exerciser and the VR headset (22 mentions each), followed closely by the robotic pet (21) and the adapted nail clipper (20). The 3D printer (19) and the food processor (12) also stood out.

This pattern combines striking and salient technologies with practical, everyday aids. However, the overall recall rate was limited: 17.8% of users did not remember any item and the average recall was 2.6 items, lower than the three items requested in the questionnaire. This may reflect cognitive limitations among a subset of participants, which should be taken into account when interpreting the findings.

The comparison between the groups reveals a modest effect of the escape room on immediate recall. Those who took part in the activity remembered an average of 2.73 items, compared with 2.42 in the group not taking part. Although this difference points towards a favourable trend, it did not reach statistical significance ($p > 0.05$) and the effect size was small.

A more detailed analysis, based on **Figure 1**, shows a distinct pattern. In the escape room group, recall increased for salient devices and demonstration equipment (VR headset, 3D printer, food processor, adjustable bed, or the Alexa voice assistant), whereas in the group without the escape room activity, small aids or those linked to daily life, such as the adapted nail clipper or the pedal exerciser, were more often remembered. The robotic pet was distributed evenly across both groups. Finally, some items, such as the comb or the grabber tool, were remembered almost exclusively by the group that did not take part in the escape room, which probably reflects differences in device availability between capsules or inconsistent naming.

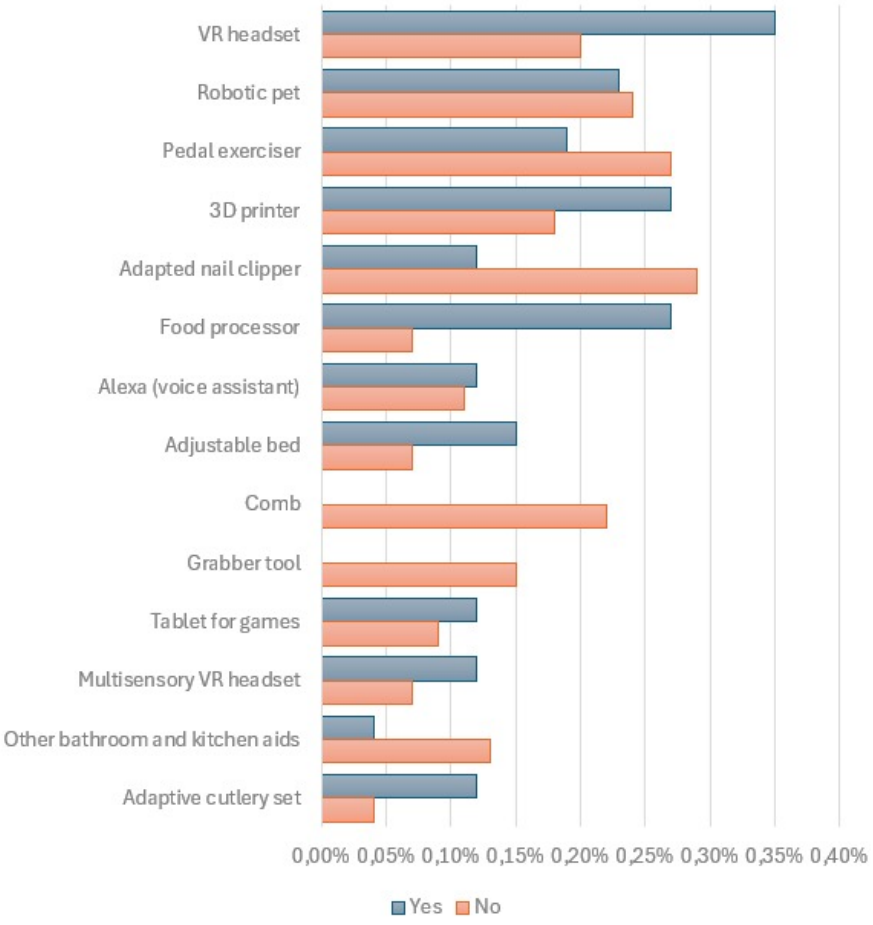

Figure 1. Recall by escape room attendance.

Another relevant aspect was willingness to bring the technologies into the home. Here a surprising pattern was observed: the intention to adopt was lower among users who took part in the escape room (38.5%) than among those who did not (61.8%), which represents a difference of 23.3 percentage points. The Pearson χ^2 test was marginally significant ($p = 0.049$), but tests with continuity correction and Fisher's exact test did not confirm significance ($p = 0.083$ and $p = 0.059$, respectively). This points to a trend towards lower willingness to adopt in the

group that carried out the activity, although statistical evidence is insufficient to assert this conclusively.

4.2. Perspective on Impact through Carers: Qualitative Analysis

The level of satisfaction observed among participants after carrying out the activity is generally considered high. The perception at the time, and even in the long term according to the carers, indicates that they remember the technology better or feel more motivated to use it when it is used through play. Some of the comments collected after observing the activity in the capsules are as follows:

- Participant 1 (older person with reduced mobility): "I really enjoyed it. I didn't think I had it in me to use a tablet to solve clues, but with some help, I did it".
- Participant 2 (person with mild cognitive impairment): "At first I found it hard to understand what to do, but then I had fun looking for clues with the robot".
- Comment from carer: "It was very rewarding to see them willing to try new things. Some were nervous at the beginning, but then they felt like the main protagonists".

Interviews with carers and practitioners added a crucial qualitative dimension. Most participants reported that the escape room reduced initial resistance, aroused curiosity, and brought technology closer to older adults through direct experience. Participants in Béjar and Toro expressed enthusiasm, curiosity, and a sense of autonomy. As one interviewee noted: "The escape room is a great icebreaker because it gives them that confidence boost of being useful... and who doesn't like feeling useful?" (BJ_1, lines 163–164).

Carers noted that, with adequate support, gamification appears to generate a positive emotional impact that encourages openness to other devices such as Alexa or emergency watches. One of the coordinators who took part in the capsules admits that "yes, there were differences. If I explain it informally, without any challenges or anything, and without paying particular attention to that, I end up losing some of them. So it was a way of drawing them into the activity" (CP_1, lines 238–241). One of the people accompanying two women who still live independently said that they found the escape room not only enriching, but that after trying out the technology they even decided to take some of the products home with them (TR_1).

Although there is broad consensus that the experience was very positive, carers observed some barriers to participation in the escape room. The first concerns the selection of participants, particularly in relation to cognitive impairment and barriers associated with literacy or language difficulties (BN_2), as well as participants with more severe cognitive impairment (SE_1 and CP_1), thereby making it necessary to provide additional support and allocate more time to ensure that the activities are completed appropriately.

Figure 2 illustrates relationships between gamification, recall, and emotional/pedagogical dimensions identified. Gamification not only increases recall but also affects crucial emotional and pedagogical dimensions that are key to technological appropriation among older adults.

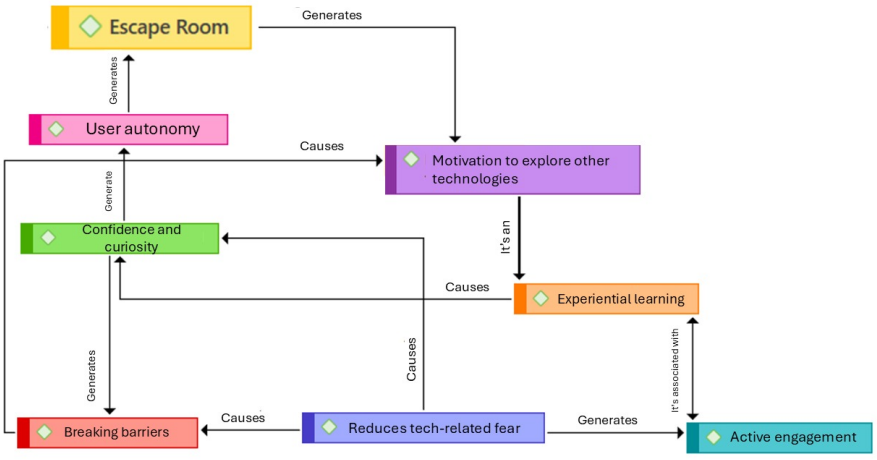

Figure 2. Effects of gamification.

4.3. Integrated Results/Triangulation

The results are presented through integration using complementary triangulation (**Appendix A**), in which the quantitative component provides the overall pattern (what occurs and with what intensity), while the qualitative component provides the interpretive mechanism (why it occurs, under which conditions, and with what nuances). Triangulation was applied in real time during the presentation of results, using common anchor points between both sets of evidence: (i) participation and group dynamics during the escape room; (ii) recall/identification of technologies; (iii) willingness to adopt or take technologies home; and (iv) attitudes and dimensions of the acceptance model (e.g., perceived utility, ease of use, behavioural intention).

The clearest convergence is that the escape room fosters initial engagement: the quantitative analysis shows high participation and positive immediate appraisal, while interviews with professionals explain that the game "breaks the ice", reduces anxiety, and activates the social component as a facilitator.

The main divergence is that the positive experience does not automatically translate into an intention to adopt or to take the technology home. The quantitative analysis reflects moderate to low levels of intention among certain profiles or contexts, which professionals attribute to day-to-day feasibility barriers (need for support, fear of "not knowing", reading or language issues, cognitive decline, costs, and management), meaning that, while the escape room facilitates trying out the technology, it does not ensure adoption without subsequent mediation.

Complementarity shows what makes the effect work (or not): recall of technologies improves when there is hands-on use + simple explanation + a link with real needs, not just exposure.

5. Discussion

The combined analysis of quantitative and qualitative results enables the identification of three key dimensions regarding the use of the escape room as a validation tool for assistive technologies: its role in processes of technological appropriation, its pedagogical function, and its potential as a device for validation and application in real-world contexts.

5.1. Technological Appropriation: Between Engagement and Adoption

The results show that the escape room successfully sparks initial interest and engagement with technology. However, this initial engagement alone does not guarantee long-term use in daily routines. This is reflected in the data: although participants in the escape room showed slightly higher levels of recall, their willingness to take the technologies home was lower than that of non-participants. This divergence between experience and behavioural intention aligns with classical models of technology acceptance, particularly the Technology Acceptance Model (TAM), which links adoption to variables such as perceived usefulness and ease of use. This limitation of the TAM among older adults is addressed by the STAM proposed by Chen and Chan [23], which incorporates health and self-efficacy to explain why positive initial experiences do not always translate into everyday adoption.

In line with these approaches, our findings suggest that while a gamified experience may improve participants' initial attitudes towards technology, this is not enough to secure sustained adoption, as observed in previous studies with older populations [22]. Factors such as perceived complexity, the need for support, or contextual constraints continue to decisively influence the integration of devices into daily life [24]. These elements are also evident in the qualitative accounts, where carers highlight difficulties related to cognitive limitations, the need for guidance, and concerns about managing the devices independently.

As outlined in the introduction, the results show that openness to technology cannot be understood solely as a stated attitude, but rather as a situated experience, in line with perspectives that emphasise the importance of the context of use in processes of technological appropriation [15,25].

5.2. Pedagogical Function: Gamification and Realism in Technological Learning

The escape room fulfils a significant pedagogical function that extends beyond technological acceptance. In keeping with the literature on gamification, which highlights its capacity to enhance motivation, engagement, and meaningful learning [9,11,15], quantitative and qualitative results indicate that the experience generates a positive emotional response and encourages active participation, mainly by reducing hesitation and encouraging participants to "give it a try". The VIVEMAIS capsules, in this sense, acted as an initial stimulus that lowered barriers and

made interacting with the technologies less intimidating.

However, the data allows us to go a step further by identifying the effects of "pedagogical realism". Unlike many studies focused on the motivational potential of gamification [3,25], our results show that direct interaction with the devices also exposes participants to practical usability challenges. This finding expands the existing literature by demonstrating that gamification not only facilitates learning but can also foster a more critical and situated understanding of technology. In this sense, the escape room aligns with experiential learning approaches, which underline the relevance of direct, situated engagement for the construction of meaning.

5.3. Application Scenario: Escape Rooms as Validation Environments

Finally, the results allow for the interpretation of the escape room as a validation tool within broader processes of technological implementation. This use extends the predominant focus in the literature, where escape rooms have primarily been applied in educational contexts [8,10,26], transferring this methodology to a less explored domain: the evaluation of technologies with end users.

Mediation emerges as a key factor in this process. Caregivers and professionals often act as intermediaries between older adults and technology [5]. This is also reflected in the empirical material: carers frequently report that participants require continuous guidance to complete tasks and to make sense of the devices, particularly in cases involving cognitive or literacy limitations. As the results show, the gamified experience proves more effective when accompanied by support, reinforcing the idea that technology adoption is deeply social and mediated.

This approach aligns with emerging perspectives on human-centred artificial intelligence and technological integration, which emphasise the importance of experiential interaction, contextual awareness, and iterative feedback processes in the adoption of digital solutions [27]. From this perspective, the escape room can be understood not only as a pedagogical tool but also as a space for transition between design, evaluation, and implementation. The results suggest that gamification through escape room dynamics can function effectively as an entry point to assistive technologies, particularly among populations that exhibit reluctance or have limited prior exposure. By creating a playful and collaborative environment [25], the activity appears to reduce anxiety and foster participants' confidence and sense of agency.

The effectiveness of the experience depends largely on the presence of pedagogical and social mediation, as well as the extent to which the technologies connect with users' daily needs and capabilities [24], especially in rural contexts characterized by connectivity barriers. Without these elements, the technological impact on adoption is limited. Therefore, escape room-based interventions should be integrated into broader strategies that include guided support, opportunities for repetition, and follow-up actions aimed at facilitating the transfer of learning to daily life. These results also support the use of structured, experiential environments as part of broader, user-centred technological ecosystems, where interaction, feedback, and contextual adaptation are key elements for successful implementation [28].

6. Conclusions

6.1. Main Contributions

This study contributes to the literature by analysing the use of the escape room not as an educational or awareness-raising tool, but as a participatory methodology for the validation of assistive technologies with older adults in rural and cross-border contexts. In doing so, it extends existing research on gamification by shifting the focus from learning outcomes towards processes of acceptance and appropriation.

A key contribution of the results is the identification of a gap between experiential engagement and behavioural intention. Although the escape room fosters curiosity, participation, and positive emotional responses, these effects do not necessarily translate into a greater willingness to adopt the technologies in daily life. This distinction nuances existing assumptions about the impact of gamification and underscores the need to differentiate between short-term effects and long-term adoption processes.

Furthermore, the study introduces the notion of "pedagogical realism," whereby practical interaction with technologies in a simulated environment not only generates enthusiasm but also increases awareness of practical usability barriers. This dual effect, aligned with meta-analyses on supervised exergames in cognitive impairment [29], positions the escape room as both a motivational and a diagnostic tool within user-centred innovation processes.

6.2. Limitations

These conclusions should be interpreted in light of several limitations arising from the exploratory and adaptive nature of the study. First, the implementation of the intervention across multiple locations, together with the logistical complexity of the mobile capsule, constrained the degree of standardisation and control over the conditions in which the experience took place.

Second, the characteristics of the participant population—individuals of advanced age, often with cognitive impairment or functional limitations, required significant adaptation of the data collection process. In many cases, the structured questionnaire had to be transformed into a highly supported and flexible interaction, which restricted the scope of the quantitative component and reinforced the relevance of the qualitative analysis.

Finally, participation in the escape room was not universal within the sample, and potential selection biases related to functional capacity, availability of support, and contextual factors cannot be ruled out. These aspects, together with the heterogeneity in implementation across locations, limit the generalisability of the findings.

6.3. Future Research Directions

Future research should build upon these findings by exploring the long-term effects of gamified interventions on the actual adoption of technologies beyond the immediate experience and stated intention. Longitudinal designs would be particularly valuable for assessing whether initial engagement can translate into sustained use over time.

Similarly, it would be pertinent to compare the escape room methodology with other participatory or experiential approaches in order to better understand its relative effectiveness across different contexts and populations. In addition, greater attention should be paid to the role of user profiles, particularly in terms of cognitive and functional differences, in shaping the experience and its outcomes.

Finally, further investigation is needed into the role of mediation and support systems, not only during the initial interaction but also throughout the processes that enable the effective integration of assistive technologies into everyday life.

Author Contributions

Conceptualization, C.M.R. and E.-M.G.-A.; methodology, C.M.R., E.-M.G.-A. and S.N.G.; validation, C.M.R., E.-M.G.-A., S.N.G. and R.E.F.; formal analysis, C.M.R. and E.-M.G.-A.; investigation, C.M.R. and E.-M.G.-A.; resources, C.M.R., S.N.G. and R.E.F.; data curation, E.-M.G.-A.; writing—original draft preparation, C.M.R., E.-M.G.-A., S.N.G., R.E.F., and J.G.-M.; writing—review and editing, C.M.R. and E.-M.G.-A.; visualization, E.-M.G.-A.; supervision, C.M.R.; project administration, S.N.G., R.E.F., and J.G.-M.; funding acquisition, J.G.-M. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Ethical review and approval were waived for this study, as confirmed by the Universidad de Valladolid, since the study did not require ethical approval.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Data is unavailable due to privacy.

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Conflicts of Interest

The authors declare no conflict of interest.

AI Use Statement

During the preparation of this manuscript, the authors used ChatGPT solely for language refinement. No AI tools were used for data analysis, interpretation, or generation of scientific content. All outputs were critically reviewed and edited by the authors. The authors take full responsibility for the integrity and accuracy of the work.

Appendix A

Table A1. Triangulation matrix.

Anchor/Indicator	Quantitative Evidence (What It Shows)	Qualitative Evidence (What It Explains/Illustrates)	Relationship (C/Comp/D)	Integrated Interpretation (Synthesis)	Practical Implication
Escape room participation and dynamics	High participation/involvement in the activity; positive immediate appraisal	Accounts about "breaking the ice", motivation through play, group effect.	Convergence	Gamification facilitates initial user engagement and reduces anxiety about technology; the social component acts as a facilitator.	Design challenge- or collaboration-based activities to maximise initial engagement.
Recall/identification of tested technologies	Differences in recall between technologies (some are remembered more than others)	Recall is associated with guided interaction, clarity of use, prior familiarity, and an understandable "name".	Complementarity	Mere exposure is not enough: recall improves when there is hands-on activity, a short explanation, and a connection to an everyday need.	Increase interaction time with each device and use simple labels/explanations.
Intention to adopt/to bring the technology into the home	Moderate/low intention in certain profiles or contexts despite positive experience	Barriers: need for support, fear of "not knowing", reading/language issues, cognitive decline, costs/management, doubts around actual utility.	Divergence (apparent) → Explained	A positive appraisal does not automatically lead to adoption: intention depends on everyday feasibility and available mediation.	Post-activity follow-up, step-by-step training, and support at home/from carers.
Perceived utility (TAM)	Association of perceived utility with behavioural intention (or with acceptance indicators)	"It's worthwhile if it really helps me/if it gives me a sense of security"; utility linked to autonomy and safety.	Convergence	Utility comes from addressing real risks (falls, medication, safety).	Present technologies based on specific and personalised problem scenarios.
Ease of use/effort (TAM)	Ease of use predicts acceptance or is related to recall/intention	"If it's complicated, I'll give up on it"; demand for simple instructions; need for repeated practice.	Convergence	Acceptance drops when cognitive load exceeds available capacity/energy; simplicity is key.	Simple interfaces, guided repetition, visual materials, and accessible language.
Cognitive barriers, literacy, and language	Subgroups with lower adoption/worse performance or greater need for support	Cases: "cannot read/language" and greater deterioration → require more time and individual support.	Complementarity	Inequality in capabilities is not marginal: it determines how effective the escape room is and the potential for adoption.	Adjust selection/pace, adapt challenges (pictograms/audio), higher support ratio.

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