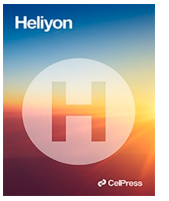
Heliyon 10 (2024) e32979

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Enhancing active aging through IRAGE: Mitigating social isolation with intergenerational gaming

Manel Díaz [a,*], Rosa M. Gil [a], Luisa F. Cabeza [b], Eva Cerezo [c], Mercè Teixidó [a]

[a] GRIHO Research Group, Department of Computer Science and Digital Design, Universitat de Lleida, Jaume II St. 69, 25001, Lleida, Spain
[b] GREiA Research Group, Universitat de Lleida, Pere de Cabrera S/n, 25001, Lleida, Spain
[c] Advanced Computer Graphics Group (GIGA), Computer Science Department, Universidad de Zaragoza, María de Luna St. 1, 50015, Zaragoza, Spain

ARTICLE INFO

Keywords:
Human-computer interaction (HCI)
Intergenerational communication
Remote access
Social isolation
Well-being
Active aging

ABSTRACT

This paper presents the outcomes of a pioneering study that explores the potential of remote intergenerational communication to combat social isolation among children and older adults, especially under constraints posed by pandemics such as COVID-19. Acknowledging the limited mobility of many older adults, this research aims to provide insights into how digital platforms can facilitate meaningful exchanges between generations. Utilizing a mixed methodology approach, the study first conducted a user interaction analysis to outline guidelines for participant engagement with the Information and Communication Technology (ICT)-based tool called IRAGE (Intergenerational Remote Access to Gaming Experiences) designed specifically for this purpose. Following the development of the ICT tool, three sessions of the remote intergenerational experience were held, during which participants' interactions were recorded and subsequently analyzed quantitatively and qualitatively. Key findings from the study reveal that remote intergenerational communication can significantly mitigate feelings of isolation among older adults, contributing to their mental health and emotional well-being. Moreover, the study highlights the effectiveness of the web-based platform in facilitating these interactions, with older adults and children finding the user interface intuitive and the overall experience engaging. These outcomes underscore the importance of leveraging technology to maintain social connections during challenging times and offer valuable guidelines for developing ICT tools that cater to the needs of diverse user groups. By demonstrating the feasibility and benefits of remote intergenerational communication, this research contributes to the broader discourse on active aging and the role of digital technologies in promoting social inclusion and emotional health.

1. Introduction

The older adult segment of the population, those aged 65 years and older, represents the fastest-growing segment [1]. The scientific community has conducted several studies on the importance of healthy aging for older adults [2–5].

Social isolation significantly affects this group's health and quality of life [6]. The COVID-19 pandemic has further intensified the social isolation experienced by older people [7,8]. This highlights the necessity of developing effective strategies to combat social isolation, which can negatively impact older adults' physical and mental health, well-being, and active aging.

* Corresponding author.
E-mail address: manel.diazllobet@udl.cat (M. Díaz).

https://doi.org/10.1016/j.heliyon.2024.e32979
Received 4 January 2024; Received in revised form 25 May 2024; Accepted 12 June 2024
Available online 17 June 2024

1.1. Intergenerational communication and older adult well-being

In this context, intergenerational communication is relevant in mitigating isolation and fostering connections between generations. Dinkins [9] stated: "*Social participation, relationships, mood, and mental health are some of the aspects of health that are achieved as a result. It has been demonstrated that the intergenerational connection provides older adults with benefits such as increased generativity, improved cognitive functioning, and a greater sense of self-worth*".

Similarly, Simionato et al. [10] suggest that programs that recognize psychosocial development, are delivered in community settings, use trained facilitators and support participants to build relationships through shared purpose are more likely to improve social health outcomes.

There is significant interest in intergenerational communication in the scientific field. For instance, Jiménez-Roger and Sanchez [11] and Silverstein et al. [12] have researched intergenerational solidarity within families. Likewise, Jothikaran et al. [13] emphasize the importance of intergenerational and inter-family care for older adults. Canedo-Garcia et al. [2] and Gualano et al. [14] state that participation in these intergenerational communication experiences has short- and long-term benefits for children and older people. Similarly, the findings of Zhong et al. [15] and Lemaire et al. [16] show that participating in intergenerational programs can improve physical and mental health, cognitive function, social relationships, and overall well-being.

Technology to achieve intergenerational communication has also been explored in several scientific articles. Reis et al. [17] discuss how technology increasingly facilitates communication and meaningful interactions between different generations, especially younger and older adults. They highlight the potential role of technology in supporting intergenerational connectivity, but note that research exploring this area is limited. The scoping review conducted in the study identifies emerging concepts, such as the focus on games. Similarly, Phang et al. [18] identify different strategies and contexts in which these programs are effective, such as access to digital technology and video calls.

Many older adults face mobility problems due to age-related medical conditions. This can prevent them from participating in intergenerational experiences, leading to a lack of health benefits [19,20]. Additionally, COVID-19 restrictions have further limited in-person participation in these experiences due to the fear of infection [21]. Several studies have been conducted on the availability and use of technology among older adults [22,23]. The results of these studies indicate that older adults are gradually adopting technology, such as digital health technologies and smart devices. Nonetheless, there are still hurdles to be cleared, and attempts are being made to account for older adults' unique requirements and difficulties in developing and implementing technology.

1.2. Contribution to the field

Research increasingly supports the efficacy of ICTtools in enhancing communication across generations. For instance, studies have documented that video calls, messaging apps, and social media platforms can significantly increase the frequency of communication between generations [24–26]. This is particularly beneficial for families spread across different geographical locations, allowing them to maintain closer ties despite physical distances. Further research indicates that older adults are primarily engaged with ICT for family and social connections, as well as accessing information [27]. Those in the 65–70 age bracket and those with higher education levels tend to be more active users. A crucial factor for this demographic is visual accessibility, which, if not addressed, can hinder their ability to use digital platforms, including accessing vital government resources [28]. Ethnographical studies reveal a strong desire among older adults to feel included and competent in using ICT, despite challenges related to cognition and usability [29]. While experience can mitigate visual and manual interaction issues, cognitive challenges often persist, suggesting a need for tailored solutions. Adaptive user interfaces are proposed to address such challenges by offering real-time personalization to meet the individual needs of older adults, accommodating common issues like cognitive decline and vision loss [30]. Enhancing web accessibility with context-sensitive aids, such as customized layouts and voice prompts, is also discussed as a means to improve the digital experience for middle-aged and older users [31]. Social media and photo-sharing apps facilitate shared experiences, allowing families to stay connected through the sharing of pictures, videos, and updates. This digital engagement offers a unique opportunity for grandparents to remain involved in their grandchildren's lives [19]. Regular ICT communication is also highlighted as a method to combat loneliness, particularly for older adults living alone, showcasing the role of digital tools in reducing feelings of isolation [32]. However, it's important to acknowledge certain caveats. The digital divide remains a barrier for some families, limiting access to technology or the skills needed to use it effectively. While ICT can increase the frequency of communication, it does not inherently ensure the quality of interactions. Moreover, digital communication cannot fully replicate the emotional depth of face-to-face interactions, which are crucial for building strong emotional bonds.

In conclusion, while ICT tools provide a valuable means to supplement and enhance intergenerational communication, they should not be seen as replacements for traditional in-person interactions. By addressing these points, our manuscript intends to clearly articulate how our study's objectives fill the existing gaps in research, reinforcing the importance of ICT in promoting meaningful intergenerational communication.

We would highlight the contribution of our study to the field in 4 aspects. (1) The Impact of Social Isolation: While the detrimental effects of social isolation on older adults' health and quality of life are well-documented, our study seeks to address the gap in research concerning effective strategies for combating this issue through intergenerational communication. The COVID-19 pandemic has exacerbated social isolation, underscoring the urgency of finding innovative solutions. (2) Benefits of Intergenerational Communication: Although the benefits of intergenerational communication for older adults, such as enhanced cognitive functioning and improved sense of self-worth, are recognized, there is a need for more empirical evidence on how specific intergenerational communication strategies can be implemented effectively. Our study contributes to this area by exploring the use of technology to

facilitate these interactions. (3) Technological Solutions for Intergenerational Communication: The potential of technology in supporting intergenerational connectivity is a promising field, yet research exploring practical implementations and outcomes of technology-facilitated intergenerational programs remains limited. Our study addresses this gap by evaluating the effectiveness of a specific ICT tool in enhancing intergenerational communication. (4) Mobility Issues and Technology Adoption among Older Adults: While mobility problems and the COVID-19 pandemic challenge older adults' participation in intergenerational experiences, there is an ongoing need to understand how technology can be tailored to overcome these barriers. Our research adds to the conversation by examining older adults' technology adoption and identifying ways to make digital platforms more accessible and user-friendly.

1.3. Theoretical framework

1.3.1. Scientific research conducted to date

To better understand the current research on remote intergenerational communication, scientific articles were searched in the Scopus and Web of Science (WoS) databases for the last ten years. The search was conducted in May 2020 and updated in September 2023. The search terms ("elderly or older adults or adult people") and "communication" and "intergenerational" and ("remote or online or on-line") were used in the title, abstract, and keyword fields. A total of 75 records were found. Duplicates were removed from each database considered (31 records removed) remaining 44 full-text documents were assessed for eligibility. After analyzing them, 5 were excluded because they did not include intergenerational communication. Additionally, 18 documents were excluded because they were on a different topic. Finally, 21 documents containing data from 16 sources, 73 authors, 79 author keywords, and 952 references were included. The average number of citations per document is 23.1.

There is a significant lack of scientific publications on remote intergenerational communication with older adults, with only 21 publications. Additionally, 73 authors have contributed to these publications, and only 5 have more than one publication. These facts highlight a significant research gap on the topic. Fig. 1 displays four critical aspects of the "remote" component, extracted from the analysis of 21 articles. The two most common aspects are using ICT and social networks (aspect number two) and the health benefits for older adults (aspect number three). On the other hand, the least common aspects are the reduction or absence of mobility (aspect number one) and computer applications developed by the authors (aspect number four). Please note that the percentages in Fig. 1 do not add up to 100 % because some documents may contain several relevant aspects.

Out of the 21 documents examined, mobility difficulties in older adults were the least addressed, with only 3 out of 21 documents covering the topic. However, in 2019, 7 out of 10 documents focused on the problems caused by the COVID-19 pandemic. The fear of COVID-19 infection has also impacted the mobility of older adults. As a result, in the post-pandemic society, older adults are experiencing increased social isolation due to these consequences [14]. The analyzed documents indicate that "social isolation" is one of the main problems affecting the health of older adults, both positively and negatively [20,33–35]. Other studies have explored the benefits of older adults engaging in intergenerational interactions through virtual tools [2], promoting health maintenance and well-being [36], coping with stress caused by COVID-19 [21], using social media for intergenerational communication with young people [37], promoting active and digital aging [38], exploring intergenerational relationships for older adults [19], and examining the psychological impact of COVID-19 on intergenerational communication [39].

The analysis of 21 articles revealed that most utilized pre-existing ICT tools such as social media platforms like Facebook, Twitter, and Instagram. However, there were six articles where the authors developed their own ICT tools for conducting research with older adults. Four such tools were developed: Photo Alive! [40,41] and Tangible Social Content Service System [35] that relied on the use of family photographs, Social Connector [33,42] that facilitated intergenerational communication via short synchronous and asynchronous messages between members of the same family, and Memotree [43] that involved creating a family tree of the participating family in an intergenerational experience. In all these ICT tools, intergenerational communication occurs between members of the same family (intrafamily). In addition, none of the four ICT tools analyzed in our qualitative study includes intergenerational

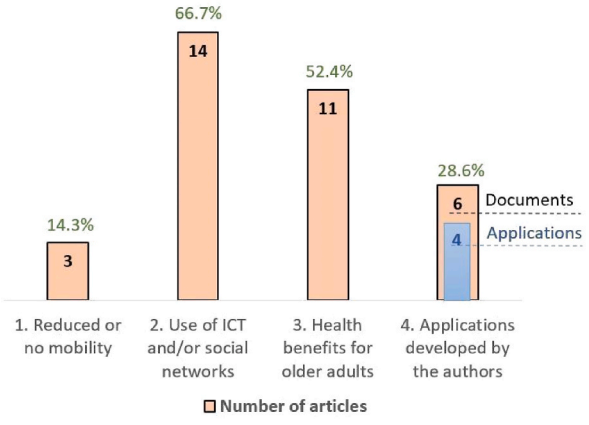


Fig. 1. Presence of four relevant aspects related to the keyword "remote".

communication with members of other families (interfamily) or a gaming component. The inclusion of interfamily communication is deemed essential for its potential to introduce diverse perspectives, increase engagement through gaming, and address the pressing issue of social isolation, enhancing mental health with innovative solutions. Our study suggests that future research and development in ICT tools for intergenerational communication should consider these aspects to maximize their impact. Table 1 shows a summary of the four ICT tools mentioned, comparing their characteristics with the ICT tool developed in this study.

This study justifies the development of a new ICT tool that enables remote intergenerational communication among older individuals. In our case, the newly developed ICT tool allows for interfamily communication and includes a story creation game to increase motivation for participation in the experience.

Table 1
Summary of the four ICT tools found.

	Summary	Users	Key elements	Gaps
Photo Alive!	Communication system using smart TV and internet browser. The objective is to establish communication by tagging and commenting on family member's photos.	-	Use of family photos. Various communication channels (Voice, SMS, Email)	☒ Competitive ☒ Collaborative ☒ Creative ☒ Game ☒ Final prize ☒ Inter-familiar communication
Tangible Social Content Service System	Communication system using TV and remote control. It can also be used on a smartphone. The objective is to communicate easily among family members.	13	Use of family photos. Use of social networks (Facebook)	☒ Competitive ☒ Collaborative ☒ Creative ☒ Game ☒ Final prize ☒ Inter-familiar communication
Social Connector	Asymmetric communication system between the members of a family. The objective is to provide older adults with technological access to family information stored in the cloud.	9	Use of short messages. Synchronous and asynchronous communication	☒ Competitive ☒ Collaborative ✓ Creative ☒ Game ✓ Final prize ☒ Inter-familiar communication
Memotree	Communication is carried out through video and chat rooms. The objective is to promote intergenerational communication through SNS	39	Build a Family Tree. Communication-based on Social Network Sites (SNS)	☒ Competitive ✓ Collaborative ✓ Creative ☒ Game ✓ Final prize ☒ Inter-familiar communication
IRAGE	Synchronous and videoconference communication. The objective is to promote intergenerational communication through a game	22	Obtain a collaboration prize through a game	✓ Competitive ✓ Collaborative ✓ Creative ✓ Game ✓ Final prize ✓ Inter-familiar comm.

1.3.2. Protocol support theories

The protocol of our study was inspired by these theories.

- ***Social Learning Theory*** [44]**:** This theory is based because it emphasizes that people learn from observing and imitating others. In an intergenerational game, players of different ages can learn from each other, making the game more engaging and educational. The video conference tool was key to achieving that.
- ***Flow Theory*** [45]: It's all about finding the perfect balance between challenge and skill. Intergenerational games need to be designed so that players of all ages can experience flow, keeping them hooked and having fun. To guarantee this, we use familiar themes for children and older people.
- ***Activity Theory*** [46]: It focuses on how people engage in activities to achieve their goals. In an intergenerational game, players of different ages can work together to achieve common goals, fostering cooperation and teamwork. A common prize at the end was the ingredient to fulfil this requirement.
- ***Intergenerational Interaction Theory*** [47]: It specifically deals with interactions between different generations. It highlights the importance of creating opportunities for meaningful connections between players of different ages in an online game. Remembering meaningful experiences offers these opportunities in the game.
- ***Motivation Theory*** [48]: It explores what drives people to engage in activities. Intergenerational games need to tap into players' motivations from different age groups to keep them interested and invested in the game. We explored this theory using mechanics as extrinsic rewards.

1.4. Objectives and research hypotheses of the study

This research aims to determine if older adults can use ICT tools to communicate remotely, reduce social isolation, and benefit from communication with their families, especially younger members. Zahn et al. [49] compared three game modalities for older people: competitive, collaborative, and creative. One of the main conclusions drawn by Zahn et al. [49] is that participating in creative games can increase verbal communication skills. Based on this finding and other considerations, we propose an experience where participants can communicate through a creative storytelling game. This experience was carried out in Spain for nine months, from September 2020 to June 2021. The game consisted of developing and explaining a story. Three sessions were conducted with 22 volunteer users, including 13 children and nine older adults.

To validate the hypothesis, the research will be guided by the following questions.

- **RQ1: What computer technology can facilitate remote interaction between children and older adults?**
- **RQ2: What should be the ideal user interface for remote intergenerational communication experiences between children and older adults?**
- **RQ3: Are ICT tools suitable for enabling children and older adults to participate in remote intergenerational communication experiences?**

The following text is a research report divided into four sections. The first section presents a user interaction analysis of an ICTtool designed to support a remote intergenerational communication experience, describing its implementation and feedback. The second section presents the results of the feedback provided by the volunteers who participated in the experience. The third section answers the research questions. Finally, the main findings and conclusions of the research are presented, including the validity of the original hypothesis.

Table 2
Platforms and their advantages and disadvantages.

Type	Advantages	Disadvantages
Desktop application	Effective tools for software development.	Difficulty of distribution and installation. Low portability. It is not designed for remote connection. Depending on the operating system.
Native mobile application	Limited power of development tools. Only mobile and tablet devices are allowed. High portability. Prepared for remote connections.	The distribution and installation required should be minimal. Depending on the operating system. The device screens are relatively small.
Web Application	Powerful development tools. Accessible from any device with internet access Very high portability. Remote connections inherent to technology Not operating system dependent No distribution or installation is required.	

2. Materials and methods

In this study, a mixed methodology approach was adopted to gain a better understanding of the topic. Firstly, a user interaction analysis was conducted to obtain guidelines for the participant's interaction with the ICT tool used in the study. Secondly, the experience and ICTtools were designed to support the study. Thirdly, three sessions of the experience were held, and the participants' comments were collected and analyzed.

2.1. Prior analytical review

To make it easier for people to use the ICT tool that will be used for the remote intergenerational communication experience in this study, we analyzed various computer development platforms. The goal was to identify the most appropriate platform for end users.

2.1.1. Platform development and deployment framework

To make the experience accessible to users with different needs, we needed to use technology that catered to their requirements. Table 2 compares the advantages and disadvantages of various development and usage platforms.

After analyzing the pros and cons of different platforms, we decided to develop a web-based system. A web system is easily accessible from any device with an internet connection, making it highly portable and available. It eliminates the need for software or operating system installations, making it easy for older adults and children to use. Moreover, participants can access the web system via video conferencing using a URL. The development and design tools for web systems are powerful, and there is a lot of information available about them. The complex animations required for the remote intergenerational communication experience we aim to create can be easily implemented in a web system, which can improve the user experience and make it even more enjoyable.

2.1.2. User interaction

Various authors have suggested guidelines for designing user interfaces suitable for older adults [50,51]. These user interfaces should be easy to navigate, intuitive, and feature non-aggressive, well-contrasted colors to accommodate age-related visual impairments. To evaluate the usability of a proposed ICT tool, two prototypes were developed, each with a different style of human-computer interaction based on the aforementioned recommendations. The prototypes were evaluated using a usability test in interviews with 18 users, consisting of 7 children aged between 7 and 16 years old and 11 adults aged over 65 years old. This evaluation of the prototype was carried out between May and June 2020. In the initial prototype, the user's interaction with the system was guided by buttons. However, in the second prototype, the interaction was directly manipulated by the interface elements. We conducted interviews to gather relevant information about age, gender, use of information technology, devices used, and the preferred interaction version (with or without buttons). Table 3 displays the results of the user interaction test that was conducted.

Based on the findings presented in Table 3, the participating children (rows 1 to 7) are split in their preference between the two versions provided in the study. Three of the children preferred the version with buttons, while four preferred the version without buttons. On the other hand, the older adult participants (rows 8 to 18) expressed a clear preference for version 1, which is the one with buttons.

Regarding technology, all participants use a device where a web page can be displayed (PC, Tablet, or mobile phone). However, for older adults, this device is usually a mobile phone. It was found that the button-guided interface was preferred by 4 out of 6 men and 8 out of 12 women, which is exactly 67 % for both genders. On the other hand, regarding the direct manipulation interface, the preference percentages are complementary for both genders, which is 33 %. Therefore, it can be concluded that gender did not influence

Table 3
Results of user interaction interviews.

N	Age	Gender	Play?	PC	Tablet	Smartphone	Version*
1	7	Woman	Yes	No	Yes	No	1
2	7	Man	Yes	No	Yes	No	2
3	9	Woman	Yes	Yes	Yes	No	2
4	9	Woman	Yes	Yes	Yes	No	2
5	10	Woman	Yes	Yes	Yes	No	1
6	10	Woman	Yes	Yes	Yes	Yes	2
7	12	Woman	Yes	Yes	Yes	Yes	1
8	66	Woman	No	No	No	Yes	1
9	66	Woman	No	No	No	Yes	1
10	66	Woman	No	No	No	Yes	1
11	67	Woman	No	Yes	No	Yes	2
12	67	Man	No	Yes	No	Yes	1
13	69	Man	Yes	Yes	No	Yes	2
14	69	Woman	No	No	No	Yes	1
15	70	Man	No	No	No	Yes	1
16	70	Man	No	No	No	Yes	1
17	74	Man	No	No	No	Yes	1
18	79	Woman	No	No	No	Yes	1

Note: * *(1) With buttons; (2) Without buttons.*

the choice of either interface.

2.1.3. Inferences derived from prior analytical review

According to the data analysis of the previous study, it has been observed that most older adults do not use their PCs or tablets regularly. Instead, they prefer using mobile phones. Furthermore, they tend to gravitate towards button-based interfaces as they are accustomed to physical buttons like the ones found on calculators. This preference can be linked to the fact that they learned computer science when touch screens were not available, and interfaces were operated with buttons. The buttons have been incorporated mainly to guide players through the game process, ensuring they always know what to do.

After reviewing the results of a previous study, it has been decided to create an interface for the button-controlled web application that will guide the entire game process. The color combinations will be soft and not very aggressive but with high contrast. In addition, the interface should have smooth animations to make it more attractive and enjoyable, increasing interest and playability. You can find an overview of how the computer application should be designed in Table 4.

2.2. Analysis of the remote intergenerational communication initiative

2.2.1. Participants

The study on remote intergenerational communication involved 22 volunteers participating in three sessions. The participants were selected from different regions of Spain, including Barcelona, Lleida, Zaragoza, and Granada. The sample consisted of 13 children below 16 and nine older adults aged 65 and above. We followed ethical protocols to ensure this research project's proper implementation. Participants signed a consent form outlining the study's purpose and objectives. In this case, informed consent has been obtained from the parents or legal guardians of the participants below 18 years of age. The parents or guardians have provided written permission, indicating their awareness of their children's participation in the activity and their understanding of the conditions. This informed consent ensures that the parents/guardians are fully informed about the nature of the activity and have given explicit approval for their underage children to participate in it. Participant consent is available upon request.

To achieve a representative sample, the following selection criteria were considered: (1) Age Range: Children participants were selected within the age range of 7–17 years, and older adults were selected with an age requirement of 65 years and above. (2) Geographical Diversity: We ensured that participants were located in various geographical areas across Spain, emphasizing the inclusion of individuals from regions far apart to capture diverse experiences and perspectives. (3) Technological Accessibility: Participants were required to have access to a device equipped with internet connectivity and a webcam, enabling their active participation in the remote intergenerational communication experience. (4) Team Composition: It was essential for the teams to consist of at least one child and one older person to participate in the experience, facilitating direct intergenerational interactions.

This experience aims to promote intergenerational communication through the use of ICT tools. Each participating team must have at least one child and one older adult. The first phase of the experience involves the creation of a story by each team based on a roll of dice. A creative play style is encouraged to facilitate communication between the participants, who, in this case, will be from different generations. In the second phase, the teams present their stories to the other participating teams and points are awarded based on specific criteria. These points will be used to determine a common final prize in the third phase, where teams must negotiate their preferences based on their earned points. This final phase includes a competitive component, which, as per Zahn et al.'s findings [49], enhances the fun of the participants.

2.2.2. Experience

During the intergenerational communication experience, a videoconferencing tool was used to facilitate remote communication between team members, participants, and researchers. This tool was the ZOOM platform [52]. During the first phase of the experience, which consisted of story creation, each team had access to a private videoconferencing room for remote communication between team members. In the second and third phases of the experience, all participants and researchers used a common videoconference room for communication. An ICT tool with web technologies has been developed from scratch to carry out the experience. The development of this web application has followed the guidelines described in the previous study (refer to Table 4). Our research team developed this tool and hosted it on a web server owned by the University of Lleida. The development and its use in the experience will be explained below.

Table 4
Design process overview.

Item	Guidelines
Technology	Web Technology
Interaction style	Button-guided direct manipulation style
Colors to use	Soft, high-contrast colors
Interface elements	Smooth animations to increase the interest and playability of the experience
Interface elements	Recognizable interface elements
Interface elements	Clear layout of screen elements: grouped and aligned elements
Theme	Friendly theme "The Garden of Dreams" (see next section)

2.2.3. Mechanics

The first step of the experience is the formation of the teams. The coordinator of the experience assigns a team to each participating group, consisting of at least one child and one older adult (Fig. 2a). During the first phase of the game, each of the participating teams is connected to a private videoconferencing room, along with a researcher from the development team. The researcher is in charge of solving technical problems, if any, and of dynamizing this part of the experience. In this phase, a child and an older adult will work together to generate a phrase. They will use this phrase to create a story to tell the rest of the teams during the second phase. The phrase is created based on three random variables. These variables are determined by rolling dice. For the first variable, a topic is chosen from six categories. The second variable is a basic emotion, selected from the six basic emotions proposed by Paul Ekman [53]: fear, anger, disgust, sadness, joy, and surprise. The third variable determines whether the story should be real or invented. To complete this project phase, an ICT tool has been developed, illustrated in Fig. 2b.

During the second phase of the experience, all the teams join together in a common videoconference room, together with the coordinator of the experience. Each team takes turns explaining its story, and the other teams try to guess the emotion provoked by the story and whether it is real or invented (Fig. 3a). Teams earn points for storytelling and predicting the emotion and type of story. This phase involves intergenerational remote communication between children and older adults, not only with people they know (members of their team, interfamily communication) but also with people they don't know (members of other teams, intrafamily communication). The points earned by participating in this phase are necessary to keep the participants motivated throughout the intergenerational communication process (Fig. 3b).

In the third phase of the experience, the teams remain in the common videoconference room with the coordinator. In this phase, all team members participate in intergenerational communication. This phase involves negotiating how to spend the points earned for a standard reward. The reward consists of constructing a "Garden of Dreams'' by obtaining different elements for the garden. Initially, the garden is empty, and each participating team must decide which elements they want to include in their garden. Throughout the process, remote intergenerational communication will be generated between the teams. During this phase, all participants are encouraged to collaborate and negotiate with each other, as everyone shares the reward. To avoid frustration among teams that may not have achieved many points, the scoring system has been designed so that each participating team can earn some rewards individually. However, the best rewards are obtained through collaboration between several or all participating teams. Fig. 4a shows the relevant part of the ICT tool for this third phase. In Fig. 4b, the final prize is displayed, along with the details achieved by teams participating in this remote intergenerational communication experience.

Table 5 shows the entire process of the experience, showing each phase's characteristics.

The ICT tool employed in this study introduces several innovative features compared to other tools analyzed, distinguishing it in the realm of digital platforms. A comprehensive analysis of various technological platforms informed the selection of a web-based platform for the tool's distribution (refer to Table 2). Furthermore, the design of user interaction with the ICT tool was meticulously crafted, drawing on insights from our prior study examining interactions between children and older adults (refer to Table 3). These elements underscore the tool's novelty in the context of this research.

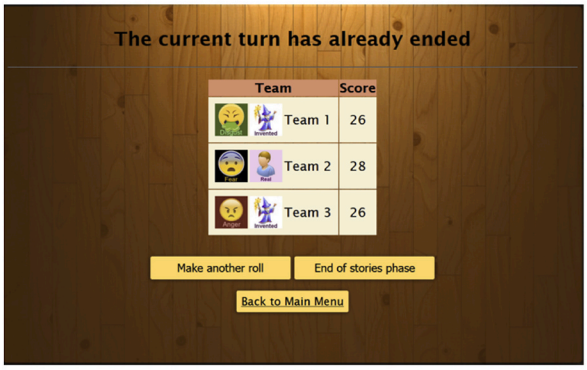
However, the most innovative aspects of the ICT tool lie in its orientation towards providing a gaming experience [17] to enhance motivation [49], coupled with its capability for remote use. This latter feature is particularly crucial as it enables participation from individuals with limited or no mobility.

2.2.4. Technical specifications of the ICT tool developed

To develop the ICT application used in this research, different prototypes of the elements that users had to manipulate have been made. Prototypes have also been made regarding the location of these elements on the screen. After carrying out the previous analysis of the interaction with the user, certain elements were discarded, and the final arrangement of the elements on the screen was chosen.

Fig. 2. The first phase of the experience.

(a)



(b)

Fig. 3. The second phase of the experience.

From this previous analysis, the conclusion was reached to create the ICT tool with web technology. A relational database was developed to manage information related to the experience. Fig. 5 shows a diagram of activities of all user interaction (including the coordinator) with the ICT tool. Fig. 6 shows the structure of the remote communication of the participants in the experience. This figure shows the typology of the videoconference rooms where the participants connect in each of the phases of the experience and their interaction with the different parts of the ICT tool developed.

Since it was necessary to implement smooth animations of the elements, the user interaction part was implemented with HTML5 + CSS3. These technologies offered very powerful tools for creating a required user interface.

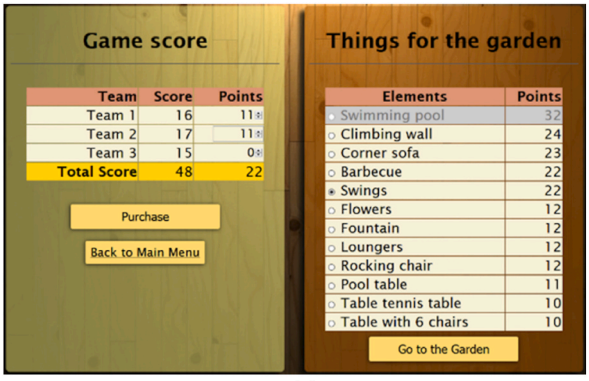
The PHP language was used for the information management part (scores, elements of the final prize, interaction management, etc.). This language allows for object-oriented programming, which is necessary due to the complexity of the developed tool. The MySQL relational database management system (RDBMS) was used to store and manage information. The PHP language has libraries specialized in connecting and processing data on this RDBMS. Fig. 7 shows the steps in the development process of the ICT tool (IRAGE) implemented.

2.2.5. Collection of feedback data

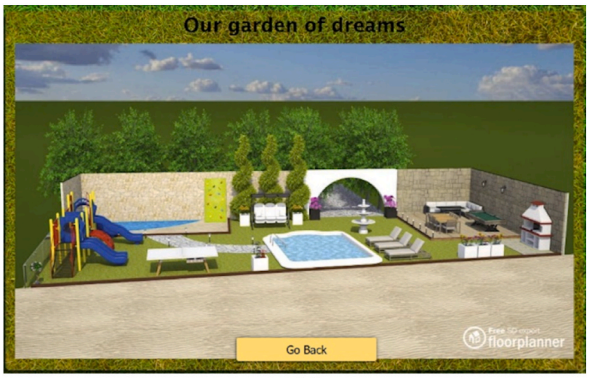
At the end of each session, the participants were asked to fill out a form to provide feedback on their experience. This feedback was later analyzed to gain insights. Table 6 in the "Results" section lists the questions from the post-test, the aspects they evaluated, and the type of answer provided. For the first two questions (Q1 and Q2), which required quantitative responses, a Likert scale [54] was used. The scale ranged from 1 (strongly disagree) to 7 (strongly agree).

It should be noted that the responses to questions Q3 to Q7 are free text, meaning participants were free to express themselves without any guidance. To make sense of these qualitative answers, each of them has been converted into a quantitative format. It's important to note that the same qualitative answer can be converted into different quantitative answers, resulting in multiple answer categories of the same question. Therefore, the sum of occurrences (Σ(n)) for questions Q3 to Q7 may not always be the same, and the count may not always be equal to the total number of participants (n = 22) in the study. To account for this, the information is also provided as a percentage.

We used questions Q1 and Q2 to evaluate the confidence generated by the web application for internet use and the usability of the ICT tool used in the experience for older adults and children. To gather users' opinions on the remote intergenerational communication experience, we individually analyzed each qualitative question (questions Q3 to Q7). The results for each question are presented in the "Results" column in the format "$n = x\ (y\%)$", where "x" represents the number of responses for each category and "y" means the



(a)



(b)

Fig. 4. The third phase of the experience.

Table 5
Characteristics of each phase of the experience.

Phase	1 Story creation phase	2 Storytelling and points collection phase	3 Negotiation and final prize obtaining phase
Communication type	Intrafamily communication	Intra and interfamily communication	Intra and interfamily communication
Duration	15 min for each group	5 min for each group	20 min for all participants
Skills [26]	Creative and collaborative	Collaborative and competitive	Collaborative and competitive
VideoConference room	Private for each team	Common for all teams	Common for all teams

percentage of total responses.

3. Results

3.1. Content analysis

Table 6 presents the question number, text, response type (qualitative and quantitative), results, and graphs.

Both children and older adults have reported that using this ICT tool has boosted their confidence in using other applications that require the use of the Internet or computing devices in general. This was revealed through their answers to questions Q1 and Q2. Additionally, both groups of users found the app's user interface easy to use. They mentioned that people unfamiliar with the app can use it easily.

According to question Q3, users participating in remote intergenerational communication have had a positive experience overall. 91 % of users (n = 20) rated their experience as good, very good, or excellent. Two users (9 %) did not respond to this question. None of the users rated their experience as "bad". When asked about the most positive aspect of the experience (question Q4), participants rated the intergenerational communication generated during the sessions as the top highlight. Out of the 20 participants surveyed, 46 % expressed their preference. Among them, 28 % considered "Being with my grandparents/grandchildren" (12 participants) as the most important factor, while 18 % (8 participants) chose "Meet other people". Interestingly, 28 % of the participants (12 in total) used the words "**being** with my grandparents" instead of "talk" or "play" in response to question Q4. The word "being" to describe the

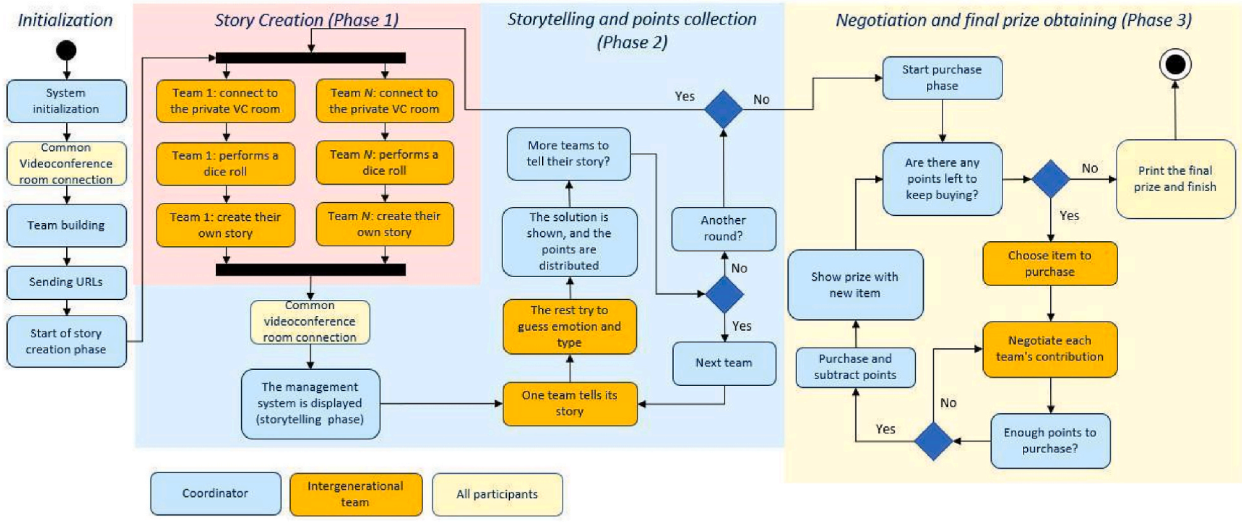


Fig. 5. Activity diagram of the whole experience.

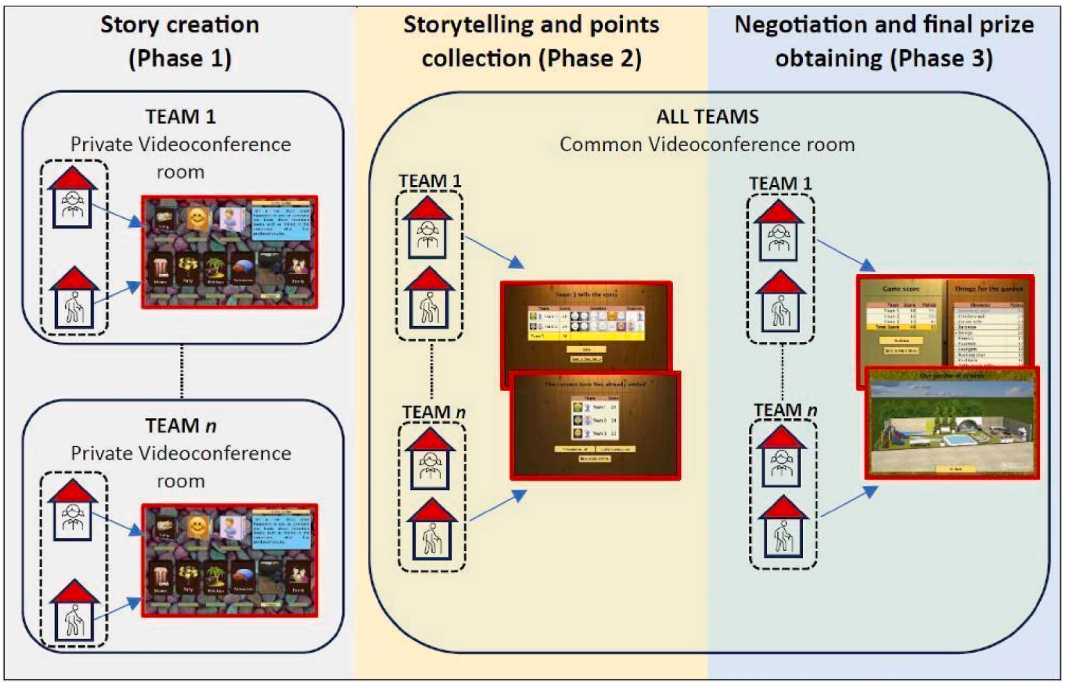


Fig. 6. Remote communication of the participating teams with the developed ICT tool in the different phases of the experience.

communication between children and older adults indicates the closeness that can be achieved through such an experience. There was a noticeable difference in the feedback received from users who participated in the game. 19 % of users (n = 8) appreciated the creativity and storytelling aspect of the game, while 21 % (n = 9) appreciated the entire game development process. Furthermore, 12 % of users (n = 5) found the remote completion of the game to be a very positive aspect due to COVID-19 safety measures. Out of all the surveyed participants, 41 % (n = 9) did not perceive any negative aspect of the experience or the use of the ICT tool (question Q5). 18 % of those surveyed (n = 4) suggested improving the scoring system would be desirable. Only 9 % of users (n = 2) encountered computer problems, such as a lack of connection or practice with the computer. Lastly, only 5 % of users (n = 1) gave negative feedbeck about the mechanics of the experience.

The participants of the remote intergenerational communication experience were asked about the most significant new features of the experience (question Q6). According to their responses, the three most notable aspects were interacting with other people (marked as 1), experiencing the remote component (marked as 2), and being protected against COVID-19 (marked as 4). These three aspects

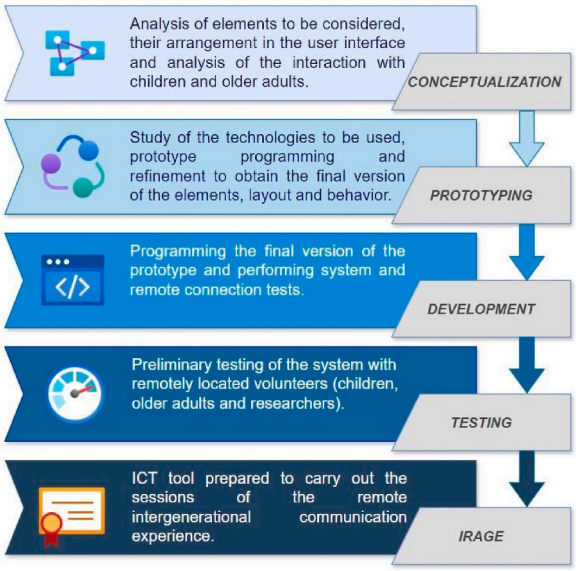


Fig. 7. Development process of the ICT tool.

represented 56 % (n = 14) of the overall experience. Additionally, 59 % of respondents (n = 13) stated they would not change or add anything to the experience or ICT tool (question Q7). However, 23 % of participants (n = 4) suggested using avatars to personalize the teams and add more emotions and categories to generate a greater diversity of stories.

Regarding the limitations, we acknowledge that the initial unfamiliarity with Video Conferencing tools among some older participants presented challenges. Our empirical evidence indicates that while a portion of the elderly population did face difficulties in adopting new technologies, many were able to overcome these barriers with proper guidance and support. This finding is critical as it underscores the importance of tailored training and support systems in facilitating the use of digital tools among older adults.

On the other hand, our study also uncovered a significant strength of our intervention: its practicality in an increasingly digital world. The empirical evidence gathered through our research demonstrates the tool's effectiveness in enhancing communication between older adults and their families. By providing a segment of the population with tools that facilitate easier communication, our solution addresses a crucial need in today's digital society. This contribution is particularly valuable given the ongoing digital transformation, which risks excluding those not proficient with new technologies.

In summary, our work allows older adults to stay connected with their families in an increasingly digital world.

3.2. *Inferential statistical analysis*

Inferential statistical analysis of the data has been performed to support the quantitative results, providing a stronger evidence base.

The number of children and older adults who participated in the experience was not equal. We thought that their opinions should be very similar. Thus, we assumed that there would not be a difference in means between the two groups.

To fit these requirements, we choose a T-test. The null hypothesis for the *t*-test of two samples with unequal variances states that the two groups have no difference in means. The typical formulation of the null hypothesis would be as follows:

Null hypothesis: The mean opinion in group 1 (children) is equal to the mean opinion in group 2 (older adults).

Regarding the p-value to reject the null hypothesis, a significance level of 0.05 (or 5 %) is commonly used. If the p-value obtained from the statistical analysis is less than 0.05, it is considered that there is sufficient statistical evidence to reject the null hypothesis and conclude that there are significant differences in means between the two groups.

It is important to mention that the p-value represents the probability of obtaining the observed or more extreme results, assuming that the null hypothesis is true. Therefore, a p-value less than 0.05 indicates that the observed results are unlikely if the null hypothesis were true, suggesting that it is more likely that there is a real difference between the means of the two groups.

We performed the statistical analysis in the file "Intergenerational_statistics.xlsx". In all cases, the p value > 0.05 indicates that we could not reject the null hypothesis. This points out that the opinions of children and older adults were not "really" different.

We also calculate the d-value, or Cohen's d for Welch test, to estimate the effect size. The Welch test is a variant of *t*-test used when the equality of variance can't be assumed. The effect size can be computed by dividing the mean difference between the groups by the "averaged" standard deviation.

Because the effect size is medium-large, it means there's a meaningful difference between the groups. That's relevant because it shows something interesting is happening. However, the p-value being greater than 0.05 might be due to a small sample size or other factors. It is being noted and will be improved in the following test. All the cases are calculated in the previous file.

Table 6
Post-test results.

Question	Question text	Response type	Results
Q1	Will playing this game improve my confidence in gaming or using the internet?	Quantitative response (1–7 on a Likert scale)	n = 03 (14 %) n = 00 (00 %) n = 00 (00 %) n = 00 (00 %) n = 04 (18 %) n = 04 (18 %) n = 11 (50 %)
Q2	Do you think people of all ages who are not familiar with online devices or the Internet could play this game?	Quantitative response (1–7 on a Likert scale)	n = 00 (00 %) n = 01 (05 %) n = 02 (09 %) n = 01 (05 %) n = 02 (09 %) n = 06 (27 %) n = 10 (45 %)
Q3	How did you feel about your experience?	1. Bad	n = 00 (00 %)
		2. Good	n = 10 (45 %)
		3. Very good	n = 05 (23 %)
		4. Excellent	n = 05 (23 %)
		5. No response	n = 02 (09 %)
Q4	What I liked the most about this experience is …	1. Spend time with grandparents/ grandchildren	n = 12 (28 %)
		2. The game	n = 09 (21 %)
		3. Socializing with others	n = 08 (18 %)
		4. Ensuring safety during COVID-19	n = 05 (12 %)
		5. Exploring creativity and story	n = 08 (18 %)
		6. No response	n = 01 (02 %)
Q5	What I liked the least about this experience is …	1. I liked everything.	n = 9 (41 %)
		2. Scoring system.	n = 4 (18 %)
		3. Disagreements.	n = 1 (04 %)
		4. Computer problems.	n = 2 (09 %)
		5. Game dynamics.	n = 1 (04 %)
		6. Others/No response.	n = 5 (23 %)
Q6	In this game, when we have been together, it has been different from other times because …	1. Relationship with others	n = 7 (28 %)
		2. Remote experience	n = 6 (24 %)
		3. Game typology	n = 1 (04 %)
		4. COVID-19 safety measures	n = 1 (04 %)
		5. Nothing new	n = 5 (20 %)
		6. No response	n = 5 (20 %)

(*continued on next page*)

Table 6 (*continued*)

Question	Question text	Response type	Results
Q7	Are you interested in introducing something new to your gaming experience?	1. Nothing further to add.	n = 13 (59 %)
		2. Include avatars.	n = 01 (04 %)
		3. More emotions and categories needed.	n = 03 (14 %)
		4. Add game dynamics.	n = 01 (05 %)
		5. No response.	n = 04 (18 %)

We have used a 95 % confidence level for mean in the calculations for Cohen's d for Welch test. With a 95 percent confidence interval, we have a 5 percent chance of being wrong.

4. Discussion

4.1. Findings from the keys studies

This section thoroughly examines the methodologies employed, the findings uncovered, and the conclusions drawn from the key studies referenced.

Impact of Social Isolation: The studies by Refs. [7,8] underline the exacerbated social isolation among older adults due to the COVID-19 pandemic. While these studies provide valuable insights into the issue, they often lack a detailed exploration of effective mitigation strategies. Our research addresses this gap by examining how remote intergenerational communication can serve as a potent strategy to counteract isolation.

Benefits of Intergenerational Communication: The work of Dinkins [9] and Simionato et al. [10] highlights the positive effects of intergenerational interaction on older adults' well-being. However, these studies sometimes do not fully explore the role of technology in facilitating such communication. Our study contributes to this area by focusing on designing and implementing an ICT tool that enhances these interactions, particularly in a remote context.

Technological Solutions and Accessibility: The findings of Reis et al. [17] and Phang et al. [18] shed light on the potential of technology in supporting intergenerational connectivity. Nevertheless, there is an acknowledged need for research into developing specific ICT tools tailored for this purpose. Our research responds to this call by not only presenting a new ICT tool but also evaluating its effectiveness and accessibility for older adults and children.

Mobility Issues and Technology Adoption among Older Adults: Previous studies [22,23] have documented the gradual adoption of technology by older adults. While these works provide an important foundation, they often overlook older adults' specific challenges and requirements in intergenerational communication contexts. Our study seeks to fill this void by offering insights into the development and usability of ICT tools that cater to the unique needs of older adults, facilitating their participation in remote intergenerational experiences.

In addition, we have made Table 5, which compares the ICT tool developed in our study with the ICT tools analyzed.

4.2. Responses to research questions

This article examines the various factors that affect remote communication experiences between generations, for both children and older adults. Based on the data analysis carried out in the previous sections, the following are the answers to the research questions that were posed.

RQ1: What computer technology can facilitate remote interaction between children and older adults?

After analyzing the findings in Tables 2 and it can be concluded that web applications are the most suitable platform for remote interaction between children and older adults. This is because web applications do not require installation, are independent of operating systems, and can be accessed from various devices. As there were no significant usability issues encountered during the remote communication experience, the web platform was an optimal choice for users conducting the tasks.

RQ2: What should be the ideal user interface for remote intergenerational communication experiences between children and older adults?

The analysis of data collected through interviews with 18 users (7 children and 11 older adults) regarding human-computer interaction in Section 2.2.3 suggests that when designing computer systems for these age groups, it is important to consider certain factors. Users prefer non-aggressive colors, buttons to guide the process, and smooth animations of the different elements to improve interest and playability. It is also important that the interface elements (such as dice and cards) are both visually and conceptually recognizable to build confidence in using the application. These findings are particularly significant for computer systems aimed at older people. Please refer to Table 4 for more details.

RQ3: Are ICT tools suitable for enabling children and older adults to participate in remote intergenerational communication experiences?

The study aimed to answer this research question by creating a real-life remote intergenerational communication experience through a game. An ICTtool was developed to support the entire experience based on the answers to research questions RQ1 and RQ2. The study found that the intergenerational communication experience helped participants gain enough confidence to use other computing devices and applications, as seen in Table 6 (questions Q1 and Q2). This result is similar to that of Gutiérrez et al. [42], who found that older adults who participated in a remote intergenerational communication experience were more comfortable with technology.

Based on the analysis of Table 6, the suggested design guidelines have been proven effective in facilitating the use of the application for both children and older adults. The average score for the usability questions, Q1 and Q2, was 5.6 out of 7 and 5.8 out of 7, respectively. This indicates that the users are highly satisfied with the ease of use of the web application they have used.

Of the 22 participants, 20 rated their experience of remote intergenerational communication as good, very good, or excellent. The participants reported that communication between children and older adults was one of the most positive aspects of the experience. Some participants used the words "being with my grandparents" to describe the physical proximity they felt during the interaction. The experience also provided a feeling of protection against COVID-19. Therefore, it can be inferred that children and older adults can engage in remote intergenerational communication experiences with the benefits that come with them, as explained earlier in this work. This is done using ICT tools that adhere to guidelines like those presented in this article.

4.3. Implications of the findings

Our study validates the suitability of intergenerational communication as an effective means to counteract the isolation experienced by older adults and to improve their emotional well-being. However, it introduces a novel approach by leveraging computer-based tools to facilitate these interactions remotely. This adaptation is particularly relevant in increasing physical distancing measures, mobility issues among older adults, and the growing need for accessible communication solutions.

By implementing and assessing the effectiveness of a specifically designed ICT tool for remote intergenerational communication, our research offers several contributions to the current understanding in this field:

Advancement of Existing Knowledge: Our results advance the existing body of literature by demonstrating that remote intergenerational communication, facilitated through ICT tools, is not only feasible but also beneficial in reducing social isolation and enhancing the emotional health of older adults. This finding is crucial as it extends the applicability of intergenerational communication strategies to settings where traditional face-to-face interactions may not be possible.

Challenging Traditional Communication Models: Our study challenges traditional models of intergenerational communication that rely heavily on physical presence and direct contact. By showing positive outcomes through remote interactions, we highlight the potential for technology to bridge the gap between generations in previously underexplored ways.

Confirmation of Theoretical Propositions: The positive outcomes observed in our study confirm theoretical propositions suggesting that social connections and meaningful interactions are vital for the well-being of older adults. Our findings reinforce the importance of social participation and relationships in promoting emotional health, aligning with previous research emphasizing these factors as critical components of active aging.

Furthermore, our study sheds light on the practical implications of using ICT tools for intergenerational communication, suggesting that with appropriate design and implementation, such tools can effectively mimic the benefits of in-person interactions. This revelation is significant as it opens new avenues for research and practice in aging, technology, and intergenerational studies.

In summary, we can address different directions by filling empirical gaps for future technology development in this area. Our research could focus on a specific under-studied demographic within intergenerational communication, like elderly populations in rural areas with limited tech experience. Additionally, many studies focus on short-term effects. Our research could examine the long-term impact of ICT use on intergenerational communication patterns and relationships, studying the evolution of a case. We can also explore how ICT use influences the quality of communication beyond just frequency, showing if people can engage in more profound conversations. Moreover, we can look at the effectiveness of other ICT tools, like virtual reality experiences or collaborative online games, in fostering connection. Regarding the theoretical implications, we find that expanding communication models is possible. Our findings could inform existing communication theories by highlighting how ICT creates new channels and dynamics in intergenerational communication. For example, our game was followed by other applications such as Discord or WhatsApp. Additionally, our research could contribute to understanding how digital literacy skills impact social integration for older adults. The digital divide can be mitigated by exploring how policies and interventions can bridge the gap in access and facilitate meaningful ICT use for all age groups. To examine the practical implications, we point out that our research can guide the creation of user-friendly and accessible ICT tools designed explicitly for intergenerational communication. The development of training programs can provide older adults with the skills and confidence to use ICT tools effectively to connect with younger generations. Furthermore, family communication strategies can give families practical guidance on leveraging ICT tools to enhance the quality and frequency of their intergenerational communication. By addressing these gaps and exploring the theoretical and practical implications, our research can significantly contribute to understanding and promoting meaningful connections across generations in our increasingly technology-driven world.

5. Conclusions

During the Spanish flu pandemic in 1918, isolating patients, and imposing restrictions on social interactions and travel bans did not entirely stop the spread of the disease. However, it did slow down its transmission [55]. In the case of the COVID-19 pandemic, social distancing measures have effectively reduced the spread of the virus and, consequently, increased the need for isolation. Previous

studies have shown that intergenerational communication experiences play a crucial role in combating isolation among people. Our study uncovered the transformative power of remote intergenerational communication in bridging the gap between children and older adults, particularly in times of social distancing necessitated by pandemics like COVID-19. By harnessing innovative information and communication technologies (ICT), this research proves the viability of such interactions and showcases their significant impact on enhancing mental and emotional well-being, thereby combating the pervasive effects of social isolation. Introducing an innovative storytelling approach has further enriched these interactions, serving as a powerful medium for personal expression and mutual understanding. Echoing the World Health Organization's emphasis on pandemic preparedness [56], our findings advocate for integrating remote intergenerational communication as a crucial strategy for maintaining social connections and fostering active aging, even in the face of future global health crises. Furthermore, the study highlights the empowerment achieved through familiarizing participants with ICT tools, demonstrating that, despite initial barriers, meaningful engagement in these digital experiences is possible and beneficial. This comprehensive exploration reaffirms the value of remote intergenerational communication for older adults' quality of life and sets a precedent for future research to build on these insights, ensuring that society is better equipped to leverage technology in sustaining intergenerational bonds amidst challenges.

6. Future work

In our future research endeavors, we aim to delve deeper into enhancing remote intergenerational communication experiences, considering the insights gained, and the limitations encountered in our current study. Specifically, we plan to focus on the following areas: (1) Improvement of ICT Tools: We acknowledge the need for more user-friendly and integrated ICT solutions to facilitate these experiences. Our goal is to develop an enhanced web application that incorporates video conferencing functionalities directly, eliminating the necessity for participants to switch between different systems. This integration aims to streamline the user experience and address one of our key limitations – the technological barriers for less tech-savvy users, particularly older adults. (2) Revision of the Scoring System: Feedback from participants indicated that the current scoring system was not as intuitive as desired. We plan to redesign this system to be more user-friendly, ensuring clarity and ease of understanding for all participants. This revision directly responds to the limitations identified in engaging participants effectively and maintaining their interest throughout the experience. (3) Expanding the Scope of Research: Encouraged by the positive outcomes of this study, we aim to broaden the scope of our research to include a wider variety of games and activities that can be facilitated through our ICT tool. This expansion seeks to address the limitation of a somewhat narrow focus in our initial study and explore the potential of remote intergenerational communication in a broader context. By conducting further intergenerational experiences of this kind, we aim to expand the initial sample to reaffirm the results obtained. (4) Addressing Geographic Limitations: A notable limitation of our study was its geographic confinement, as we restricted participation to individuals within Spain to ensure a common language, thus avoiding the barrier of differing languages.

Also, integrating custom conversation topics could be done by creating a list and using mechanisms like rolling a die or spinning, choosing one. Additionally, the importance of improving app graphics for aesthetic appeal and improving accessibility has been highlighted, including audio descriptions and pictogram adaptations for inclusivity. These improvements aim to serve a broader audience, including those with visual impairments, underscoring the need to create inclusive digital spaces. Future research avenues may include investigating the impact of these features on user experience and inclusion. By addressing diverse user needs and preferences, such as offering various levels of conversation for different purposes, we can improve our understanding of the effective design of digital communication tools. This approach not only enriches our application, but also contributes to the broader field of accessible and engaging technology development.

In conclusion, by critically reflecting on the limitations of our current study, we are committed to advancing our research in remote intergenerational communication. We believe these focused efforts will contribute significantly to overcoming the identified challenges and enhancing these experiences' efficacy and impact. We invite fellow researchers to engage with our work and further explore the vast potential of ICT in bridging generational gaps and fostering meaningful connections.

Data availability statement

The source code for this study can be found at:
https://drive.google.com/file/d/1rEE1XpDt7mapLdN0B8JCN6ffFjblycCh/view?usp=sharing.
A comprehensive guide and manual for the software developed in this study can be found at:
https://drive.google.com/file/d/1YoH23BPOTMYPSQw5i_0paekmETXBvQti/view?usp=sharing.
Additionally, the participants' responses are available at:
https://docs.google.com/spreadsheets/d/1cliQILXaNLv91xeex0W3L4PYGiTsJgCJ/edit?usp=sharing&ouid=111840715154669972624&rtpof=true&sd=true.

Funding statement

This work has been partly financed by the National Research Agency (AEI) and the EU (FEDER) through the contract RTI2018-096986-B-C31 (UZ) ó RTI2018-096986-B-C32 (UGr).

Ethical approval

Participants in this study explicitly consented to participate in the experience and surveys. See below for ethical approval information.

CRediT authorship contribution statement

Manel Díaz: Writing – review & editing, Writing – original draft, Validation, Software, Project administration, Investigation, Formal analysis, Data curation. **Rosa M. Gil:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Luisa F. Cabeza:** Writing – review & editing, Validation. **Eva Cerezo:** Methodology, Conceptualization. **Mercè Teixidó:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interestsEva Cerezo reports financial support was provided by Spain Ministry of Science and Innovation. Luisa F. Cabeza reports financial support was provided by Catalan Institution for Research and Advanced Studies. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e32979.

References

[1] L.B. Shrestha, Population aging in developing countries, Health Aff. 19 (2000) 204–212, https://doi.org/10.1377/hlthaff.19.3.204.
[2] A. Canedo-García, J.-N. García-Sánchez, D.-I. Pacheco-Sanz, Benefits, satisfaction and limitations derived from the performance of intergenerational virtual activities: data from a general population Spanish survey, Int. J. Environ. Res. Publ. Health 19 (2022) 401, https://doi.org/10.3390/ijerph19010401.
[3] L.C. Behr, A. Simm, A. Kluttig, Grosskopf (großkopf), A. 60 Years of healthy aging: on definitions, biomarkers, scores and challenges, Ageing Res. Rev. 88 (2023), https://doi.org/10.1016/j.arr.2023.101934.
[4] W. Lu, H. Pikhart, A. Sacker, Domains and measurements of healthy aging in epidemiological studies: a review, Gerontol. 59 (2018) E294–E310, https://doi.org/10.1093/GERONT/GNY029.
[5] T. Abud, G. Kounidas, K.R. Martin, M. Werth, K. Cooper, P.K. Myint, Determinants of healthy ageing: a systematic review of contemporary literature, Aging Clin. Exp. Res. 34 (2022) 1215–1223, https://doi.org/10.1007/s40520-021-02049-w.
[6] C.M. Perissinotto, I. Stijacic Cenzer, K.E. Covinsky, Loneliness in older persons: a predictor of functional decline and death, Arch. Intern. Med. 172 (2012) 1078–1083, https://doi.org/10.1001/archinternmed.2012.1993.
[7] S. Schroyen, N. Janssen, L.A. Duffner, M. Veenstra, E. Pyrovolaki, E. Salmon, S. Adam, Prevalence of loneliness in older adults: a scoping review, Health Soc. Care Community (2023) 7726692, https://doi.org/10.1155/2023/7726692.
[8] K. Roy, S. Smilowitz, S. Bhatt, M.L. Conroy, Impact of social isolation and loneliness in older adults: current understanding and future directions, Current Geriatrics Reports 12 (2023) 138–148, https://doi.org/10.1007/s13670-023-00393-5.
[9] C.S. Dinkins, Socrates café for older adults: intergenerational connectedness through facilitated conversation, J. Psychosoc. Nurs. Ment. Health Serv. 57 (2019) 11–15, https://doi.org/10.3928/02793695-20181212-04.
[10] J. Simionato, H. Vally, D. Archibald, Circumstances that promote social connectedness in older adults participating in intergenerational programmes with adolescents: a realist review, BMJ Open 13 (2023) e069765, https://doi.org/10.1136/bmjopen-2022-069765.
[11] B. Jiménez-Roger, M. Sánchez, Intergenerational contact and solidarity, inside and outside the family: patterns in Spain, Ageing Soc. 43 (2023) 421–446, https://doi.org/10.1017/S0144686X21000659.
[12] M. Silverstein, S.J. Conroy, D. Gans, Beyond solidarity, reciprocity and altruism: moral capital as a unifying concept in intergenerational support for older people, Ageing Soc. 32 (2012) 1246–1262, https://doi.org/10.1017/S0144686X1200058X.
[13] T.A.J. Jothikaran, A. Meershoek, L. Ashok, A. Krumeich, Views and experiences of adult children concerning intergenerational relationships with their older kin: a qualitative study from south India, Ageing Soc. 43 (2023) 373–392, https://doi.org/10.1017/S0144686X21000593.
[14] M.R. Gualano, G. Voglino, F. Bert, R. Thomas, E. Camussi, R. Siliquini, The impact of intergenerational programs on children and older adults: a review, Int. Psychogeriatr. 30 (2018) 451–468, https://doi.org/10.1017/S104161021700182X.
[15] S. Zhong, C. Lee, M.J. Foster, J. Bian, Intergenerational communities: a systematic literature review of intergenerational interactions and older adults' health-related outcomes, Soc. Sci. Med. 264 (2020) 113374, https://doi.org/10.1016/j.socscimed.2020.113374.
[16] C. Lemaire, C. Humbert, C. Sueur, C. Racin, Use of digital technologies to maintain older adults' social ties during visitation restrictions in long-term care facilities: scoping review, JMIR Aging 6 (2023), https://doi.org/10.2196/38593.
[17] L. Reis, K. Mercer, J. Boger, Technologies for fostering intergenerational connectivity and relationships: scoping review and emergent concepts, Technol. Soc. 64 (2021) 101494, https://doi.org/10.1016/j.techsoc.2020.101494.
[18] J.K. Phang, Y.H. Kwan, S. Yoon, H. Goh, W.Q. Yee, C.S. Tan, L.L. Low, Digital intergenerational program to reduce loneliness and social isolation among older adults: realist review, JMIR Aging 6 (2023), https://doi.org/10.2196/39848.
[19] Z. Gantumur, M. Baez, N.-E. Ulamnemekh, F. Ibarra, S. Myagmarjav, F. Casati, Effects of sharing old pictures with grandchildren on intergenerational relationships: protocol for a randomized controlled trial, JMIR Research Protocols 9 (2020) e16315, https://doi.org/10.2196/16315.
[20] Y. Yuan, S. Yarosh, Beyond tutoring: opportunities for intergenerational mentorship at a community level, in: Proceedings of the Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, May 2 2019, pp. 1–14.
[21] N. Khalili-Mahani, S. Elbaz, A. Pahayahay, J. Timm-Bottos, Role of social media in coping with COVID-19 stress: searching for intergenerational perspectives, in: G. Meiselwitz (Ed.), Proceedings of the Social Computing and Social Media: Applications in Marketing, Learning, and Health, Springer International Publishing, Cham, 2021, pp. 373–392.

[22] R.A. Mace, M.K. Mattos, A.-M. Vranceanu, Older adults can use technology: why healthcare professionals must overcome ageism in digital health, Transl Behav Med (2022) ibac070, https://doi.org/10.1093/tbm/ibac070.
[23] M.T. Harris, K.A. Blocker, W.A. Rogers, Older adults and smart technology: facilitators and barriers to use, Front. Comput. Sci. 4 (2022).
[24] K. Jenkins, K.C.-Y. Sun, Digital strategies for building spiritual intimacy: families on a "wired" camino, Qual. Sociol. 42 (2019) 567–585, https://doi.org/10.1007/s11133-019-09432-0.
[25] S.S.K. Lam, ICT's impact on family solidarity and upward mobility in translocal China, Asian J. Commun. 23 (2013) 322–340, https://doi.org/10.1080/01292986.2012.739186.
[26] F. Colombo, P. Aroldi, S. Carlo, "I use it correctly!": the use of icts among Italian grandmothers in a generational perspective, Human Technology 14 (2018) 343–365, https://doi.org/10.17011/ht/urn.201811224837.
[27] K.G. Vroman, S. Arthanat, C. Lysack, "Who over 65 is online?" Older adults' dispositions toward information communication technology, Comput. Hum. Behav. 43 (2015) 156–166, https://doi.org/10.1016/j.chb.2014.10.018.
[28] S.A. Becker, E-government visual accessibility for older adult users, Soc. Sci. Comput. Rev. 22 (2004) 11–23, https://doi.org/10.1177/0894439303259876.
[29] S. Sayago, P. Forbes, J. Blat, Older people becoming successful ICT learners over time: challenges and strategies through an ethnographical lens, Educ. Gerontol. 39 (2013) 527–544, https://doi.org/10.1080/03601277.2012.703583.
[30] E. Machado, D. Singh, F. Cruciani, L. Chen, S. Hanke, F. Salvago, J. Kropf, A. Holzinger, A conceptual framework for adaptive user interfaces for older adults, in: Proceedings of the 2018 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), March 2018, pp. 782–787.
[31] S.M.A. de Lara, D. Oliveira, R.P.M. Fortes, Context sensitive accessibility aid to middle-aged adults and elderly users in web systems, in: Proceedings of the Proceedings of the 29th ACM International Conference on Design of Communication, Association for Computing Machinery, New York, NY, USA, October 3 2011, pp. 33–36.
[32] R. Latikka, R. Rubio-Hernández, E.S. Lohan, J. Rantala, F.N. Fernández, A. Laitinen, A. Oksanen, Older adults' loneliness, social isolation, and physical information and communication technology in the era of ambient assisted living: a systematic literature review, J. Med. Internet Res. 23 (2021) e28022, https://doi.org/10.2196/28022.
[33] D. Muñoz, R. Cornejo, F.J. Gutierrez, J. Favela, S.F. Ochoa, M. Tentori, A social cloud-based tool to deal with time and media mismatch of intergenerational family communication, Future Generat. Comput. Syst. 53 (2015) 140–151, https://doi.org/10.1016/j.future.2014.07.003.
[34] G. Casanova, S. Abbondanza, E. Rolandi, R. Vaccaro, L. Pettinato, M. Colombo, A. Guaita, New older users' attitudes toward social networking sites and loneliness: the case of the oldest-old residents in a small Italian city, Social Media + Society 7 (2021) 20563051211052905, https://doi.org/10.1177/20563051211052905.
[35] M.Z. Syeda, M. Park, Y. Kim, Y.-M. Kwon, Tangible social content Service system: making digital technology easier to use by elderly and its usability evaluation, in: L. Barolli, N. Javaid, M. Ikeda, M. Takizawa (Eds.), Proceedings of the Complex, Intelligent, and Software Intensive Systems, Springer International Publishing, Cham, 2019, pp. 873–883.
[36] H. Köttl, V. Gallistl, R. Rohner, L. Ayalon, "But at the age of 85? Forget it!": internalized ageism, a barrier to technology use, J. Aging Stud. 59 (2021) 100971, https://doi.org/10.1016/j.jaging.2021.100971.
[37] T. Nef, R.L. Ganea, R.M. Müri, U.P. Mosimann, Social networking sites and older users – a systematic review, Int. Psychogeriatr. 25 (2013) 1041–1053, https://doi.org/10.1017/S1041610213000355.
[38] D. Han, K.L. Braun, D. Han, K.L. Braun, Promoting active ageing through technology training in korea, Available online: https://www.igi-global.com/gateway/chapter/www.igi-global.com/gateway/chapter/46732. (Accessed 5 June 2022).
[39] W.W.S. Tam, S.N. Poon, R. Mahendran, E.H. Kua, X.V. Wu, Impacts of COVID-19 and partial lockdown on family functioning, intergenerational communication and associated psychosocial factors among young adults in Singapore, BMC Psychiatr. 21 (2021) 595, https://doi.org/10.1186/s12888-021-03599-z.
[40] M.Z. Syeda, Y.-M. Kwon, Photo alive! Application and method for intergenerational social communication, in: Proceedings of the 2017 19th International Conference on Advanced Communication Technology (ICACT), February 2017, pp. 326–332.
[41] M.Z. Syeda, M. Park, Y.-M. Kwon, Photo alive!: elderly oriented social communication Service, , in: L. Barolli, O. Terzo (Eds.), Proceedings of the Complex, Intelligent, and Software Intensive Systems, , Springer International Publishing, Cham, 2018, pp. 805–816.
[42] F.J. Gutierrez, S.F. Ochoa, J. Vassileva, Mediating intergenerational family communication with computer-supported domestic technology, in: C. Gutwin, S. F. Ochoa, J. Vassileva, T. Inoue (Eds.), Proceedings of the Collaboration and Technology, Springer International Publishing, Cham, 2017, pp. 132–147.
[43] T.-H. Tsai, H.-T. Chang, Y.-L. Ho, Perceptions of a specific family communication application among grandparents and grandchildren: an extension of the technology acceptance model, PLoS One 11 (2016) e0156680, https://doi.org/10.1371/journal.pone.0156680.
[44] A. Bandura, The Social Learning Theory of Aggression, vol. 1, Routledge, 2019. ISBN 978-1-00-023507-4.
[45] C.-C. Liu, A Model for Exploring Players Flow Experience in Online Games, vol.30, Information Technology and People, 2017, pp. 139–162, https://doi.org/10.1108/ITP-06-2015-0139.
[46] V. Kaptelinin, A. Bonnie, N. Acting with technology, Available online: https://mitpress.mit.edu/9780262513319/acting-with-technology/. (Accessed 6 February 2024).
[47] K. VanderVen, Intergenerational theory: the missing element in today's intergenerational programs, in: Intergenerational Programs: Understanding what We Have Created, 2013, pp. 33–48. ISBN 978-1-135-78720-2.
[48] P. Felicia, Motivation in games: a literature review, Int. J. Comput. Sci. 11 (2012) 4–14.
[49] C. Zahn, D. Leisner, M. Niederhauser, A.-L. Roos, T. Iseli, M. Soldati, Effects of game mode in multiplayer video games on intergenerational social interaction: randomized field study, JMIR Form Res 6 (2022) e29179, https://doi.org/10.2196/29179.
[50] A.I. Grimaldo, A.L. Morán, E.C. Gamez, P. Cairns, R.R. Palacio, V. Meza-Kubo, Promoting elderly-children interaction in digital games: a preliminary set of design guidelines, in: N. Baloian, F. Burstein, H. Ogata, F. Santoro, G. Zurita (Eds.), Proceedings of the Collaboration and Technology, Springer International Publishing, Cham, 2014, pp. 169–176.
[51] M. Rice, Y.L. Cheong, J. Ng, P.H. Chua, Y.-L. Theng, Co-creating games through intergenerational design workshops, in: Proceedings of the Proceedings of the Designing Interactive Systems Conference, Association for Computing Machinery, New York, NY, USA, June 11 2012, pp. 368–377.
[52] M.M. Archibald, R.C. Ambagtsheer, M.G. Casey, M. Lawless, Using zoom videoconferencing for qualitative data collection: perceptions and experiences of researchers and participants, Int. J. Qual. Methods 18 (2019), https://doi.org/10.1177/1609406919874596.
[53] P. Ekman, W.V. Friesen, P. Ellsworth, Emotion in the Human Face: Guidelines for Research and an Integration of Findings, Elsevier, 1972. ISBN 978-1-4831-4763-5.
[54] R. Likert, S. Roslow, G. Murphy, A simple and reliable method of scoring the thurstone attitude scales, J. Soc. Psychol. 5 (1934) 228–238, https://doi.org/10.1080/00224545.1934.9919450.
[55] Y. Zhou, A. Draghici, J. Abbas, R. Mubeen, M.E. Boatca, M.A. Salam, Social media efficacy in crisis management: effectiveness of non-pharmaceutical interventions to manage COVID-19 challenges, Front. Psychiatr. 12 (2022), https://doi.org/10.3389/fpsyt.2021.626134.
[56] World must Be ready to respond to next pandemic: WHO chief | UN, News (2023) (Accessed June 7, 2023) Available online: https://news.un.org/en/story/2023/05/1136912.