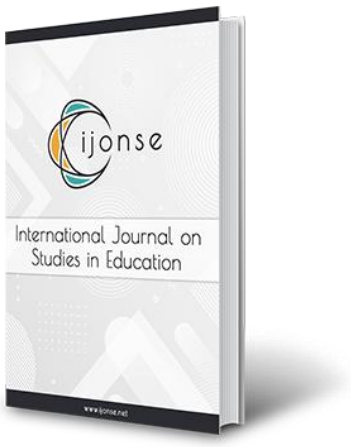


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# Intergenerational Methods to Promote Digital Application Usage among Older Adults: A Scoping Review

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# Intergenerational Methods to Promote Digital Application Usage among Older Adults: A Scoping Review

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## Abstract

The increase in the aging population highlights the importance of digital literacy for improving the quality of life of older adults. Despite their interest in incorporating digital technology into their daily lives, numerous studies have shown that older adults often struggle with its use due to a lack of learning interest, poor memory retention, and improper instruction. To address these challenges, a scoping review was conducted, drawing from 14 eligible articles sourced from Web of Science and Scopus. The review aimed to identify recent intergenerational methods that effectively facilitate the adoption of digital applications among older adults. The findings were categorized into five intergenerational methods: collaborative, virtual meeting, co-activity, family intergenerational learning, and reverse mentoring. Within these categories, the study identified key elements crucial for the success of technology-based intergenerational programs, including creating clear objectives and goals, developing comprehensive planning and structure, demonstrating effective recruitment, providing training and support, offering facilitation, ensuring flexibility and adaptability in content, and conducting thorough evaluation and feedback. By exploring these elements, this paper provides valuable insights for researchers seeking to develop and understand how technology-based intergenerational programs are conducted.

## Introduction

In recent years, the advancement of digital technology has made topics such as aging society and digital literacy become critical topics in areas of research, as improving digital literacy among older adults is essential for their full participation in an increasingly digital world (Tomczyk et al., 2023). This advancement has caused the quality of life to improve significantly and increases the interest of older adults in using these digital technologies. Examples of digital technologies inline with older adults are the: (1) digital applications, (2) internet usage, (3) services application systems, (4) use of new software and (4) use of latest virtual reality machines (Appel et al., 2022; Bahadori et al., 2024; Nedeljko et al., 2021; Pew Research Center, 2023). A study conducted by Pew Research Center (2023), states 88% of older adults aged 65 and above have started to use the Internet in 2023 and this number keeps increasing every year due to the increment of the aging population.

According to the United Nations (UN), older adults are defined as individuals aged 60 years and above (Scherbov & Sanderson, 2019). However, in Malaysia, older adults are defined as those aged 65 and above (Kementerian Pembangunan Wanita Keluarga dan Masyarakat, 2020; Scherbov & Sanderson, 2019). The increase in the aging population is attributed to lower birth rates and higher life expectancy among older adults (Gerland et al., 2022). Furthermore, the World Health Organization (WHO) (2022) states, older adults aged 60 years and above will constitute a ratio of 1 in 6 people. Between 2015 and 2050, the WHO projects that the proportion of the older adult population will increase from 12% to 22% of the world's population. In Malaysia, the Department of Statistics Malaysia (DOSM) (2023) has indicated that the country is experiencing a demographic shift toward an aging society, with the population aged 65 years and above increasing from 7.2% in 2022 to 7.4% in 2023, reflecting a global trend observed by WHO.

The increase in the aging population in older adults underscores the importance of digital literacy for improving their quality of life (Czaja et al., 2006; Freeman et al., 2020; Sixsmith et al., 2022). However, numerous barriers prevent older adults from using digital applications effectively, one of which is cognitive decline (Köttl et al., 2021). Although older adults may be interested in incorporating digital technology into their daily lives (Matenga-Ikihele et al., 2023; Wang et al., 2022; Yurtseven Avci & Eren, 2023), numerous studies have shown that they still struggle with its use due to a lack of learning interest (Mohd Zaid et al., 2023), poor memory for retaining instructions (Köttl et al., 2021), and improper instruction (Ahmad et al., 2022). Previous studies have also shown that one of the best approaches to help older adults better improve their digital literacy is by implementing intergenerational programs. (Ahmad et al., 2022; Cheng et al., 2022; Matenga-Ikihele et al., 2023; Yurtseven Avci & Eren, 2023). Intergenerational program (IP) is an effective practice for facilitating older adults in adopting digital applications, as it promotes cooperation, interaction, and knowledge exchange between generations (Wu & Chiou, 2023). IPs promote learning in informal settings, which appeals to older generations as they enjoy sharing their experiences and opinions, particularly with younger generations (Chen et al., 2021).

Thus, this study will employ the scoping review literature review to examine recent and previous studies that have used intergenerational methods and to discuss how this method can effectively facilitate the adoption and usage of digital applications among older adults. This study will also benefit instructional designers with insights from recent and previous studies on how to implement intergenerational methods to help promote digital application usage among older adults.

## Methods

The scoping review method has been selected for this study to identify recent intergenerational methods that effectively facilitate the adoption of digital applications among older adults. The study follows the framework outlined by Arksey & O'Malley (2005), which includes five stages: (1) identification of the research question, (2) identification of relevant studies, (3) selection of published articles, (4) charting of the data, and (5) summarizing the collected data. Figure 1 illustrates the scoping review framework, providing a visual representation of the study process.

To establish meaningful objectives and eligibility criteria for the scoping review, sufficient information is required (Peters et al., 2020). The population, concept, and context (PCC) framework, recommended by the Joanna Briggs Institute (JBI) is applied to construct the research question (Salmond & Bennett, 2021). This framework guides the study in identifying potential data items of interest and can be used as a search strategy by breaking down the research questions into separate components (Aromataris & Munn, 2020; Pollock et al., 2023), the research question can be the foundation to lead the study to find the most related information and data from previous studies.

The objective of the study is to identify effective intergenerational methods to promote digital application usage among older adults. Based on this objective, and the implementation of the PCC framework, the research question can be formulated as *How do intergenerational methods effectively facilitate the adoption and usage of digital applications among older adults?* This research question will help to identify the relevant article in the selected online databases such as Web of Sciences and Scopus. Okoli (2015) stated, the research question can be used to construct the search keywords to find corresponding articles.

Table 1. Search Strings

| Database | Search string |
|---|---|
| Web of Science | **TS** = (("effect*" **OR** "benefit*" **OR** "advantage*" **OR** "outcome*") **AND** ("digital* application*" **OR** "digital*" **OR** "application*" **OR** "software") AND ("strateg*" **OR** "method*" **OR** "design*" **OR** "instruct*" **OR** "teach*" **OR** "instruction* strateg*" **OR** "instruction* design*" **OR** "instruction* method*") **AND** ("intergeneration* approach*" **OR** "intergeneration*" **AND** ("Elder*" **OR** "older*" **OR** "senior*" **OR** "older* adult*")) |
| Scopus | **TITLE-ABS-KEY** ((“effect*" **OR** "benefit*" **OR** "advantage*" **OR** "outcome*”) **AND** (“digital* application*" **OR** "digital*" **OR** "application*" **OR** "software”) **AND** (“strateg*" **OR** "method*" **OR** "design*" **OR** "instruct*" **OR** "teach*" **OR** "instruction* strateg*" **OR** "instruction* design*" **OR** "instruction* method*”) **AND** (“intergeneration* approach*" **OR** "intergeneration*") **AND** (“Elder*" **OR** "older*" **OR** "senior*" **OR** "older* adult*" )) |

Constructing the search keywords can be aided by an online thesaurus, which helps refine the search engine queries in selected databases, resulting in a list of possible terms used by related authors. The search keywords, combined with Boolean operators (AND/OR), truncation, and wildcards, are embedded together to form a search string as shown in Table 1.

This search string is then submitted to the search engine's input section to produce search results of relevant and related articles. Both databases were used due to their high usage among researchers and the numerous advantages they offer, such as advanced search functions, extensive findings from over 5000 publishers, and the quality preservation of articles (Gusenbauer & Haddaway, 2020; Martín-Martín et al., 2018). Additionally, these databases provide multidisciplinary resources (Ahmad et al., 2022). Salmond and Bennett (2021) have stated the

specification of the article selection is required to prevent bias in the review and promote the validity of the findings. In determining the specification of which articles are prominent to be included in the review, the selected articles should have more than one author that used similar methods of intergenerational, this can ensure the most influential decisions can be identified in the review process (Higgins & Deeks, 2008). Based on Table 2, the study has listed the inclusion and exclusion of the selected articles to find the most relevant results in the databases. This method will assist in the finding of homogeneous articles, that can ensure the adequacy of related contents (Salmond & Bennett, 2021). The listed criterion is filtered by using databases' features.

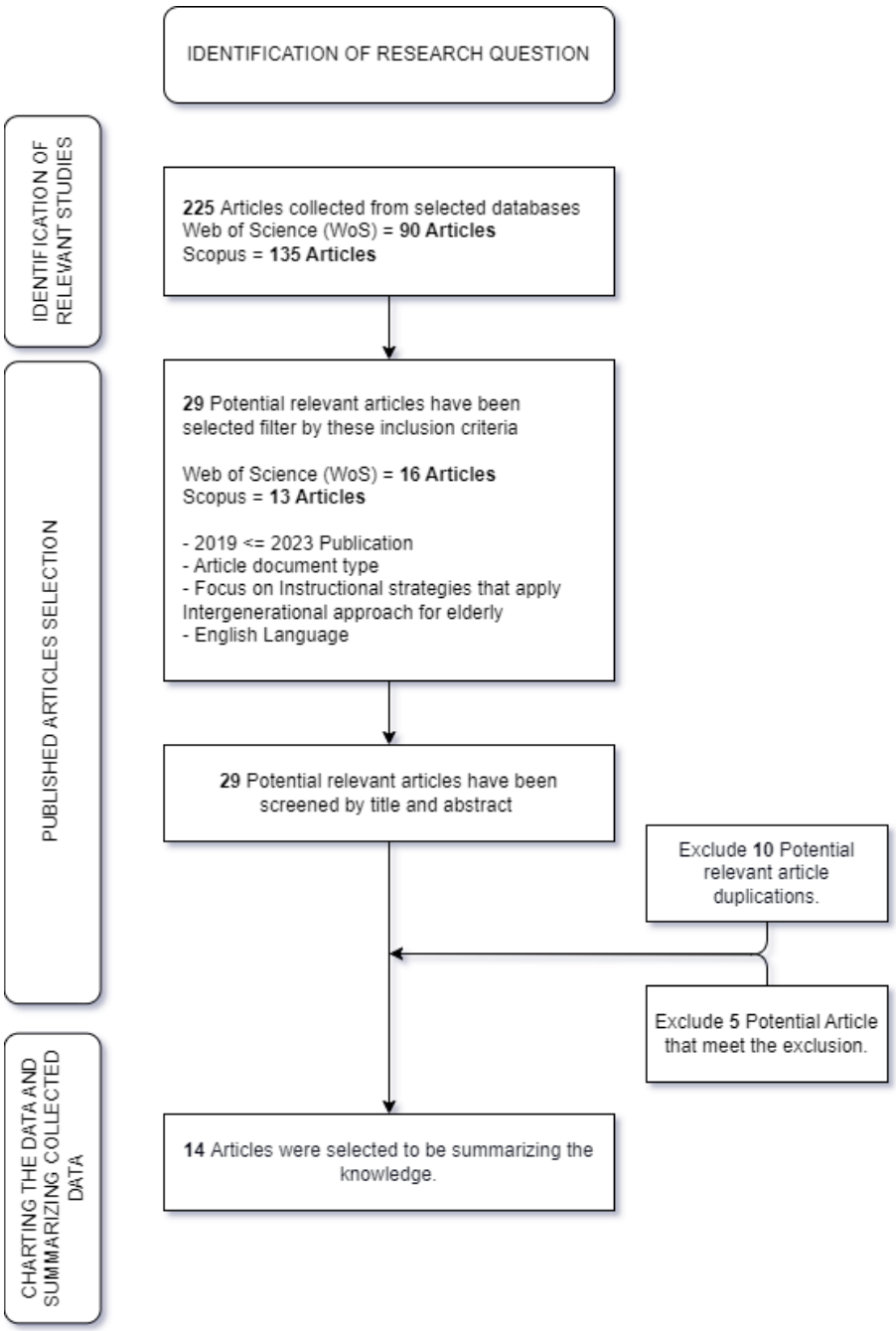


Figure 1. Scoping Review Framework Flow

Okoli (2015) has suggested the determination of publication dates post-search initiation, one example of the

inclusion of selected articles is the publications spanning from 2019 to 2023, this timeframe was chosen due to the priority of the recent study continuation. Choosing the recent 5 years back was also suggested by Higgins and Deeks (2008) because it helps to minimise the risk of publication duplications by considering distinct periods of time. The duplication of search results from both databases will be excluded to prevent any redundancy of data. Next, the articles selected are strictly to the "*article*" document type, and language preferences are English, to ensure the quality of the review and prevent any mistranslations, confusion, and misunderstanding that may arise during the review process as mentioned by Ahmad et al. (2022). Each article selected from databases will be screened and excluded if the articles are deemed irrelevant to intergenerational methods and intergenerational aspects (Higgins & Deeks, 2008).

Table 2. Inclusion and Exclusion Criteria

| Criteria | Inclusion | Exclusion |
|---|---|---|
| Publish years | 2019 until 2023 | Less than 2019 |
| Document type | Article | Book, Chapter in book, Book series, Conference Proceeding, Review Article |
| Language | English | Non-English |
| Approach/Focus | Instructional strategies, Intergenerational for elderly | Other approach, too-medical centered, application development, intergenerational for younger generation, application design |

The relevant articles were organized according to the research questions, and the data were analysed to identify the methods implemented and issues discussed in previous studies. The extracted information addressing the research questions was categorized in a table, which aids in visualizing the data more clearly and facilitates the summarization of information. Table 3 displays the intergenerational methods used in previous studies, including the years, authors, title, advantages, disadvantages, setting and method.

Table 3. The Intergenerational Methods

| Years | Authors | Title | Advantages | Disadvantages | Setting | Method |
|---|---|---|---|---|---|---|
| 2023 | (Mannheim et al., 2023) | An "ultimate partnership": Older persons' perspectives on age stereotypes and intergenerational interaction in co-designing digital technologies | - Promote interaction between generations<br>- Inclusive recruitment<br>- Structured focus groups<br>- Reduced boundaries, ageism and age-stereotype<br>- Improve cohesion between generation<br>- Contribute with rich and valuable experiences<br>- Iterative process | - The technology tested unsuitable<br>- Lack of iteration in some activities<br>- Limited designer perspectives<br>- Limited cultural context | Face-to-Face | Collaborative |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2022 | (Wang et al., 2022) | Construction of a Tangible VR-Based Interactive System for Intergenerational Learning | - Engagement and interest<br>- Emotional communication<br>- Experience sharing<br>- Stimulate interest in technology | - The design and interface are not well-designed<br>- Learning content insufficient<br>- Compromise in interactions<br>- Limit accessibility | Face-to-Face | Collaborative |
| 2023 | (González-Afonso et al., 2023) | Is Virtual Communication Possible in Intergenerational Programs? The SIMUL Project | - Creation of intergenerational meeting spaces<br>- Voluntary participation<br>- The intergenerational relationship established<br>- Reduced age-stereotype<br>- Promote cohesion | - Communication barriers in virtual format<br>- Limited informal interaction<br>- Unbalanced number of participants<br>- Technical difficulties<br>- Lack of spontaneity and flexibility | Online | Virtual meeting, Collaborative |
| 2022 | (Appel et al., 2022) | VRCHIVE: experiences conducting an online workshop teaching intergenerational participants to create virtual reality films about their lives during the COVID pandemic | - Structured workshop with clear objectives<br>- Iterative improvement and flexibility<br>- Community and technological impact<br>- Participant engagement and satisfaction | - Technical challenges and remote instruction<br>- Interaction and engagement limitations<br>- Equipment and logistical issues<br>- Short duration | Online | Virtual meeting, Collaborative |
| 2022 | (Brandão et al., 2022) | Playing remotely in times of crisis: A program to overcome social isolation | - Inclusive and diverse sampling<br>- Digital inclusion efforts<br>- Feasibility and acceptability<br>- Interdisciplinary and collaborative approach<br>- Person-oriented community holistic approach | - Dependence on in-person support<br>- Technical difficulties<br>- Limited generalizability<br>- Recruitment challenges | Online | Virtual meeting |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2023 | (Dorris et al., 2023) | Project Unmute: A Digital Music Program Delivered by Adolescent Musicians to Older Adults with Cognitive Decline | - Flexible program structure<br>- Skill development for adolescent musicians<br>- Promote interaction between generations.<br>- Demonstrated an ease with technology.<br>- Collaborative effort | - Limited program scalability.<br>- Technical difficulties<br>- Lack of training for adolescent musician | Online | Virtual meeting |
| 2022 | (Salehzadeh Niksirat et al., 2022) | Understanding intergenerational fitness tracking practices: 12 suggestions for design | - Motivation for physical activity<br>- Enhanced social interaction<br>- Overcoming technology barriers | - The design was not intuitive or easy to use.<br>- Short study duration<br>- Order effect<br>- Technology barriers<br>- Lack of playfulness | Face-to-Face & Online | Co-Activity |
| 2020 | (Lee et al., 2020) | Life Review Using a Life Metaphoric Game to Promote Intergenerational Communication | - Structured activity design<br>- Variety of communication themes<br>- Participants' age variety<br>- Game design elements analysis<br>- Fosters learning between generations<br>- Improves perceptions of different age groups | - Short duration<br>- Technological barriers<br>- Unsuitable cultural relevance<br>- Emotional Discomfort<br>- Lack of depth in young partners' training<br>- Asymmetrical communication | Face-to-Face | Co-Activity |
| 2021 | (Lee et al., 2021) | Mobile Game Design Guide to Improve Gaming Experience for the Middle-Aged and Older Adult Population: User-Centered Design Approach | - Holistic approach<br>- Facilitated social interaction<br>- Provided support to older adults during gameplay<br>- User-centered design | - Limited generalizability<br>- Short duration and limited game selection<br>- Potential bias in intergenerational interactions<br>- Technological barriers | Face-to-Face | Co-Activity |
| 2022 | (Cheng et al., 2022) | Bridging the Digital Divide for Rural Older Adults by Family Intergenerational Learning: A Classroom Case in a Rural | - Inclusion criteria<br>- Customized learning content<br>- Cost effective<br>- Promote cohesion<br>- Mutual benefits | - Potential for exclusion<br>- Lack of long-term evaluation<br>- Limited observational data<br>- Self-reporting bias<br>- Limited | Face-to-Face & Online | Family intergenerati on-al learning |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Primary School in China | | generalizability | | |
| 2023 | (Matenga-Ikihele et al., 2023) | Navigating digital inclusion and the digital vā among Niue mamatua through the provision of mobile phones during COVID-19 | - Culturally aligned methodology<br>- Inclusive sampling<br>- Bilingual communication<br>- Intergenerational support | - Limited geographical scope<br>- Challenges with mobile data costs<br>- Visual and physical difficulties<br>- Dependence on family members | Face-to-Face & Online | Family intergenerati on-al learning |
| 2023 | (Yurtseven Avci and Eren 2023) | Intergenerational Interdisciplinary Reverse Mentoring: School-University Collaboration | - Professional development for preservice teachers.<br>- Microteaching practice<br>- Intergenerational and interdisciplinary collaboration | - Logistical challenges<br>- Technical difficulties<br>- Time constraints<br>- Uncontrolled flexibility | Face-to-Face | Reverse mentoring |
| 2019 | (Leedahl et al. 2019) | Implementing an Interdisciplinary Intergenerational Program Using the Cyber Seniors ® Reverse Mentoring Model Within Higher Education | - Interdisciplinary approach<br>- Flexible models<br>- Training for students<br>- Mutual benefits<br>- Promote open sharing | - Variability in participation<br>- Technological and logistical issues | Face-to-Face | Reverse mentoring |
| 2023 | (Leedahl et al. 2023) | Using a Quasi-Experimental Study to Examine Program Participation and Outcomes for Older Adult Intergenerational Technology Program Participants | - Bridge the generation gap.<br>- Connect generations in meaningful ways.<br>- Building positive attitudes<br>- Personalized learning | - Limited generalizability | Face-to-Face | Reverse mentoring |

## Results and Discussion

Based on Table 3, there are 14 articles from the Web of Science and Scopus databases that are closely related to technological intergenerational methods emerging in recent years. These studies indicate that most previous

research aims to reduce the gap between older adults and digital technology by employing various intergenerational methods. The primary goals are to enhance digital literacy and increase the willingness of older adults to adopt digital technology in their daily lives, thereby improving their quality of life. Intergenerational methods can be classified into five types mainly:

(1) collaborative,
(2) virtual meeting,
(3) co-activity,
(4) family intergenerational learning and
(5) reverse mentoring.

Each of these methods employ different solution to help promote digital application usage among older adults. The subsection below, further describes each of these methods.

**Collaborative**

A collaborative method can be defined as an intergenerational program that includes structured interactions and mutual activities designed to promote interaction and knowledge exchange between different age groups (Wang et al. 2022). This method allows participants to brainstorm, work together, and share their opinions to gain more insight and new experiences. Further, Mannheim et al. (2023) and Wang et al. (2022) both highlighted the need to utilize the collaborative method to promote interaction and knowledge sharing related to digital technology, while working together towards a common goal.

Mannheim et al. (2023) conducted collaborative method to investigate the perspectives and experiences of older adults who participated in the co-design of various digital technologies. Older adult participants were asked to bring pictures, photos, or objects associated with digital technology as probes to elicit better responses and initiate discussions. Participants introduced themselves and shared their ideas on technology using the items they had brought. This method helped older adults point out negative aspects of existing technology, allowing designers to note these problems and consider them during the design process. The method promoted interaction between designers and older adults, reduced age stereotypes, and encouraged older adults to contribute to their generation (Mannheim et al. 2023). The study aimed to have a long-term effect on promoting the use of digital technology among older adults.

Another study conducted by Wang et al. (2022) involved collaborative activities to promote interaction between older adults and younger generations using an interactive system based on virtual reality (VR) and tangible user interfaces (TUIs). The collaboration focused on intergenerational learning, where both older adults and younger participants worked together to learn and engage with new technology. Older adult participants wore a VR headset (HTC VIVE) to immerse in a VR environment and perform puppet gestures using a Leap Motion sensor for gesture detection. Meanwhile, their grandchildren or children interacted with the system by hitting musical instruments, such as a drum and a gong, to create sound effects detected by a sound-sensing device. The study found that integrating VR and TUIs significantly increased the engagement and interest of both younger and older participants (Wang et al. 2022). Young generations were particularly attracted to the interactive elements, such as

playing the drum and gong, and older participants were more willing to join in, influenced by the children's enthusiasm.

**Virtual Meeting**

During the COVID-19 pandemic, many studies faced interaction limitations that necessitated the implementation of virtual meetings. A virtual meeting is an online gathering where participants from different locations connect using digital tools and platforms. Previous studies have used platforms such as Google Meet, Zoom, and Google Hangouts for virtual interactions with older adults. These platforms enabled continued engagement and communication despite physical distancing requirements. The flexibility of these platforms allowed researchers to conduct various activities in the virtual sessions (Brandão et al. 2022), providing a variety of intergenerational meeting spaces, especially in informal settings (González-Afonso et al. 2023). Unfortunately, this method faced common challenges such as technical difficulties (Appel et al. 2022; Brandão et al. 2022; González-Afonso et al. 2023).

One study conducted by González-Afonso et al. (2023) aimed to understand the socio-educational experiences gained during the virtual implementation of the intergenerational project called SIMUL and to identify the challenges and benefits associated with virtual intergenerational communication. The study used Google Meet to group participants, including young people and older adults, to collaborate on a common project. During the sessions, a monitor facilitated the sessions, maintained a positive atmosphere, and adapted activities as needed. The common project was presented to the community at the end of the program.

Another example is the research conducted by Appel et al. (2022), which explored the feasibility and effectiveness of a remote intergenerational VR storytelling workshop. This workshop contributed to digital literacy and social connectedness during the COVID-19 pandemic, a time marked by social isolation. The study implemented multiple methods within a single intergenerational program, such as remote workshops and collaborative activities. The sessions were conducted weekly via video conferencing, covering topics such as filming 360° videos, creating storylines, uploading files, and watching films on a VR headset. The workshops were adaptive based on participant needs, dedicating more time to equipment training if necessary. Additionally, the study was also implementing collaborative method because, at the end of the program, the older adults and grandchildren had the opportunity to work together to complete a simple VR film creation task.

A third study, conducted by Brandão et al. (2022), aimed to examine the feasibility of an intergenerational remote intervention program designed to promote the well-being and social connection of vulnerable older adults, particularly those with aphasia and dementia, in southern Brazil. During the program, participants were provided with tablets and internet access, along with remote support from undergraduate students and family members or social educators. The study's program, called "Playful Living," included a variety of art-related activities such as clowning, dancing, storytelling, and cooking, conducted via Zoom once a week for 60 minutes over three months.

Lastly, the study conducted by Dorris et al. (2023) explored the feasibility of digital music programming and

identified the potential mutual benefits for both adolescent musicians and older adults with cognitive decline. The adolescent musicians were asked to develop three different 25 minutes music programs based on the song preferences of the older adults. Each of these music programs was required to incorporate three major activities: (1) music appreciation, (2) music theory, and (3) interaction. Additionally, the adolescents had the freedom to create materials and select musical topics to make the program more engaging. They performed their music programs individually for a group of older adults once per week for three weeks as part of the BriTE program, conducted virtually via Zoom. During the program, BriTE's staff provided essential support in educating older adults and caregivers on how to use Zoom.

**Co-Activity**

Co-activity refers to multiple individuals performing activities in the same environment or context, emphasizing simultaneous or parallel action. In a technology-based intergenerational context, co-activity focuses on interaction and cooperation to foster meaningful connections, bridge the age gap, and create opportunities for shared learning and enjoyment (Lee et al. 2020; Salehzadeh Niksirat et al. 2022). Co-activity methods can be implemented online or face-to-face, depending on the context and needs of the study, and usually the programs are set in informal settings (Salehzadeh Niksirat et al. 2022).

A previous study conducted by Salehzadeh Niksirat et al. (2022) aimed to understand how intergenerational fitness tracking practices can enhance social interactions between older and younger family members, increase physical activity, and address technological barriers faced by older adults. The study used a fitness tracking app as a probe, pairing young people with older adults to use the app on their smartphones. Conducted over four weeks, the study was divided into two phases: two weeks of individual use of fitness trackers and two weeks of intergenerational use. During the individual use phase, participants explored the app's features independently, monitoring their fitness activities such as floors climbed, steps taken, heart rate, and sleep patterns while becoming familiar with the app's user interface. In the subsequent intergenerational phase, participants used the app together with their partners, engaging in daily tracking and sharing of fitness data and encouraging mutual monitoring through the app.

Another study conducted by Lee et al. (2020) explored whether intergenerational play, through a life metaphoric game, can effectively facilitate communication between senior participants and young adult partners during a life review activity. Participants were paired for the workshop, with young partners paired with multiple seniors due to an imbalance in numbers. The researchers used a mobile game called "Long Journey of Life," which metaphorically depicts life stages. The workshop activity structure consisted of three steps: (1) co-playing, (2) pair discussion, and (3) focus group interviews. Each pair was provided with a 10-inch tablet for the co-playing session, which lasted 20 to 30 minutes. The young participant guided the older participants in game playing and asked questions to promote reminiscence, while the researcher provided minimal help, intervening only if necessary.

The design of the game is crucial for enhancing the user experience (Lee et al. 2021). A study conducted by Lee

et al. (2021) aimed to improve the understanding of older adults' gaming experiences and provide concrete recommendations for game designers to create more accessible and satisfying mobile games for middle-aged and older adults. The workshop was conducted twice a week for four weeks, resulting in eight sessions, each lasting 1 to 2 hours. Each session included four components: (1) a short lecture, (2) co-playing, (3) survey and pair discussion, and (4) group discussion. During the lectures, participants received instructions on how to play specific games and enhance their game literacy. In the co-playing part, older participants were paired with young partners to play the games. Each pair received a 10-inch tablet or could use their personal smartphone. The final component of the session involved a survey, and discussions conducted after co-playing. Participants completed a survey on satisfaction levels for each game element, while pair and group discussions were held to share gameplay experiences and design recommendations.

**Family Intergenerational Learning**

Family intergenerational learning in a technological context can be defined as the exchange of knowledge and skills between generations within a family, particularly focusing on the use and understanding of technology. This method can promote relationship enrichment, foster mutual respect, and enhance digital literacy among family members, especially older adults (Cheng et al. 2022; Matenga-Ikihele et al. 2023). It also provides customized learning content tailored to the needs of older adults, which is cost-effective (Cheng et al. 2022) and promoting digital technology usage (Matenga-Ikihele et al. 2023).

A study conducted by Cheng et al. (2022) aimed to explore the effectiveness of the Family Intergenerational Learning (FIL) Project in helping rural older adults gain digital literacy and bridge the digital divide through intergenerational learning within families in a classroom setting in China. The implementation of the FIL project was carried out collaboratively with school teachers and researchers. Grandchildren were encouraged to teach their grandparents about digital applications and basic digital skills based on the grandparents' needs and interests. The primary interaction between the grandchildren and grandparents in the FIL Project was conducted face-to-face at home. This home-based learning approach allowed for a more practical and individualized strategy, addressing the specific needs and interests of rural older adults. The intergenerational learning process was tracked via a WeChat group to gather feedback from the participants regarding their feelings and experiences. Every week during the three-month duration of the project, each intergenerational pair was asked to complete a learning record form together and submit it to the researchers.

Another study conducted by Matenga-Ikihele et al. (2023) aimed to understand how the provision of mobile phones contributed to digital inclusion, digital skills, and well-being for older adults during COVID-19 in New Zealand. Due to lockdown restrictions, the study was conducted over the phone, with all conversations recorded using a digital audio recorder. Culturally aligned conversations, referred to as "*tutala*," were held with the older adults to gather their experiences and perspectives regarding digital inclusion, digital skills, well-being, intergenerational support, challenges, and benefits of using digital technology. The researchers focused on the feedback provided by the older adults, and the intergenerational interaction was primarily held at home.

**Reverse Mentoring**

In a technological context, reverse mentoring can be defined as a process where younger individuals, who are proficient with digital technology, mentor seniors or older adults. This concept aims to enhance the communication skills of the younger generation and expand the knowledge of both generations (Leedahl et al. 2019; Leedahl et al. 2023; Yurtseven Avci and Eren 2023). Reverse mentoring promotes flexibility in terms of model or phase implementations, helping researchers tailor the program to meet the needs of older adults (Leedahl et al. 2019; Yurtseven Avci and Eren 2023).

One study conducted by Yurtseven Avci (Yurtseven Avci and Eren 2023) provides insights into the effectiveness of intergenerational interdisciplinary reverse mentoring within a school-university collaboration context and suggests improvements for future applications. The study was conducted in two phases to provide learning content to in-service teachers, including microteaching and training phases. During the microteaching phase, preservice teachers conducted demonstrations on using technologies in teaching, observed by their peers and in-service teachers. At the end of the sessions, preservice teachers received feedback from their peers and the in-service teachers to improve their teaching methods and technology implementation. This phase was followed by the teacher training phase, conducted weekly based on the lesson plans developed by the preservice teachers. These sessions provided in-service teachers with hands-on demonstrations and practice in using various educational technologies. Finally, the classroom observation phase involved implementing technology in real classroom settings, supported by the preservice teachers. This phase was observed to identify the effectiveness of these applications.

Leedahl et al. (2019) conducted a study aimed at promoting civic engagement and service learning for college students, preparing future health and human service professionals, and enhancing social connectedness and technological interest among older adults. The study employed flexible reverse mentoring models, including individual appointments, matching programs, and drop-in sessions, to personalize interactions between students and older adults. Individual sessions provided personalized technology assistance, fostering close relationships. The matching program paired gerontology students with older adults based on interests and technology use, while drop-in sessions offered on-demand support. Using a quasi-experimental design, the study found that participants showed significant improvements in digital competence, reduced loneliness, increased community service activities, and more positive attitudes towards young people compared to non-participants, highlighting the program's effectiveness (Leedahl et al. 2023).

**Key Elements Towards a Successful Technology-Based Intergenerational Method Program**

An in-depth review of the procedures and methods used in each of the 14 articles discussed above has revealed seven key elements that contribute to the success of obtaining the best research or project outcomes in an intergenerational program (refer to Figure 2). Each of these key elements will be further discussed in the following paragraphs.

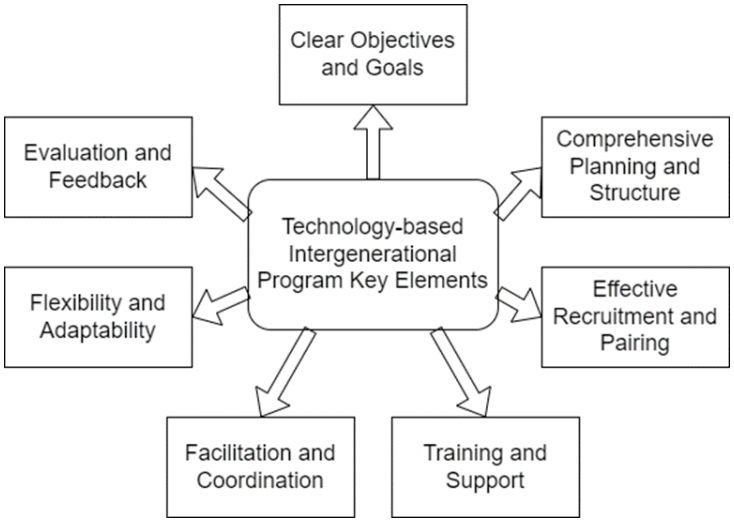


Figure 2. Technology-Based Intergenerational Program Key Elements

Firstly, the program should have clear objectives and goals. Establishing clear objectives is fundamental for creating a well-structured program. By defining specific, measurable, achievable, relevant, and time-bound (SMART) criteria, the program can be meticulously planned, ensuring that each component aligns with the overarching goals. This approach allows for careful consideration of the reasons behind each criterion, as highlighted by Bjerke & Renger (2017). For instance, study conducted by Matenga-Ikihele et al. (2023) and Cheng et al. (2022) demonstrated how setting precise objectives tailored to the family relationship context led to more adaptable and informal settings, such as home-based intergenerational activities. These settings not only accommodated diverse needs but also generated more relevant and insightful data for the evaluation process. By focusing on clear objectives, the program can better address the specific needs of participants and improve its overall effectiveness. This careful planning and alignment with SMART criteria ensure that the program remains focused and achieves its intended outcomes

Secondly, comprehensive planning and structuring of the program must include determining the suitable schedule, location, and activities (Appel et al. 2022; Mannheim et al. 2023; Lee et al. 2020). Careful consideration must be given to scheduling the program, which should encompass overall workshop preparation, participant selection, resource allocation, and the workshop delivery medium (Appel et al. 2022). Additionally, the program's location is crucial, comfortable and quiet meeting rooms facilitate interaction between generations and should limit sessions to 1.5 hours, as highlighted by Mannheim et al. (2023). Furthermore, selecting appropriate activities in the program is essential to avoid emotional discomfort for older adult participants. For instance, games with metaphoric elements that are not culturally relevant can cause unease (Lee et al. 2020). By meticulously planning these aspects, the program can achieve a more effective and engaging outcome

Next, participant selection is crucial to ensure effective recruitment, especially when the program involves older adults (Lee et al. 2020; Lee et al. 2021; Brandão et al. 2022). It is important to base the selection of participants on the appropriate program context. Previous studies have reported using participants who are: (1) older adults, (2) from low socio-economic backgrounds, and (3) with medical history issues, or experiencing negative emotional states, can provide different program outcomes. Additionally, the level of enthusiasm and commitment

from participants can significantly impact the program's effectiveness and engagement (Appel et al. 2022; Dorris et al. 2023; Wang et al. 2022).

Next, providing participants with training and support during the initial program phase is essential. This training helps both generations understand their responsibilities and roles. Understanding their roles, young people learn proper manners for interacting with older participants, effective communication, and are informed about project objectives and processes, as seen in the studies by González-Afonso et al. (2023) and Lee et al. (2020). Informing both generations in this manner can reduce age stereotypes and improve mutual understanding (González-Afonso et al. 2023). Improving mutual understanding, providing participants with props and program materials can enhance their experience and lead to meaningful interaction. Enhancing their experience, studies by Appel et al. (2022), Lee et al. (2020, 2021), and Wang et al. (2022) provided participants with devices such as applications, tablets, and VR headsets. Providing these tools helped older adults experience digital technologies and provide feedback based on their experiences.

Next, facilitation and coordination enhance program flow and ensure smooth operation. Operation of the program benefits from having a dedicated coordinator or facilitator who helps participants when problems arise and keeps them engaged and motivated. For example, the study by Brandão et al. (2022) had a student maintain contact with older adult participants, send reminders, and provide technological support, while family members or social educators offered in-person support when necessary. Necessary support was also provided in the study by Dorris et al. (2023), where a facilitator educated older adults and caregivers on how to use Zoom. Using Zoom effectively is especially important for programs conducted online, which often struggle with technical issues (Appel et al. 2022; Brandão et al. 2022; Dorris et al. 2023; González-Afonso et al. 2023).

Next, program flexibility is crucial for adapting to the needs and preferences of participants. Flexibility in the program includes being open to changes in scheduling, content, and methods of interaction. For instance, some participants may have limited time but are still interested in the program. This situation occurred in the study by Yurtseven Avci and Eren (2023), where preservice teachers faced challenges managing their time due to intensive preparation phases and materials for microteaching applications. However, flexibility can also be a drawback if not managed properly. The same study by Yurtseven Avci and Eren (2023) encountered issues with intense and tiring activities because preservice teachers had to mentor in-service teachers based on their preferences, and some preservice teachers struggled with certain technologies. A positive example of program flexibility is the study by Leedahl et al. (2019), which proposed three types of models—individual appointments, matching programs, and drop-in sessions—that accommodated both generations' preferences and availability.

Lastly, implementing evaluation and feedback through surveys, interviews, and observations helps understand the program's impact and identify areas for improvement. Evaluations, such as those conducted in studies by Lee et al. (2021), Leedahl et al. (2023), and Mannheim et al. (2023), gathered feedback on content, procedures, props, participants' perspectives, feelings, and experiences during the post-program phase. This feedback provides valuable data that helps future programs avoid the mistakes made in previous ones and enhance their effectiveness.

## Conclusion

This scoping review has identified recent intergenerational methods that effectively facilitate the adoption of digital applications among older adults. These methods include collaborative, virtual meeting, co-activity, family intergenerational learning, and reverse mentoring approaches. Each of these methods illustrates how researchers have implemented successful technology-based intergenerational programs in recent years. Despite some limitations inherent in each study, which resulted in specific disadvantages, the majority of the studies highlight key elements crucial for successful technology-based intergenerational programs. These elements encompass creating clear objectives and goals, developing comprehensive planning and structure, demonstrating effective recruitment, providing training and support, offering facilitation, ensuring flexibility and adaptability in content, and conducting thorough evaluation and feedback. By examining these elements, this review provides valuable insights for researchers aiming to develop and understand effective technology-based intergenerational programs.

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