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REVIEW PAPER

Barriers and wellbeing-oriented enablers of intergenerational innovation in the digital age

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Abstract

So far, researchers have used a wellbeing-centered approach to catalyze successful intergenerational collaboration (IGC) in innovative activities. However, due to the subject's multidisciplinary nature, there is still a dearth of comprehensive research devoted to constructing the IGC system. Thus, the purpose of this study is to fill a research void by providing a conceptual framework for information technology (IT) system designers to use as a jumping-off point for designing an IGC system with a wellbeing-oriented design. A systematic literature study was conducted to identify relevant terms and develop a conceptual framework based on a review of 75 selected scientific papers. The result consists of prominent thematic linkages and a conceptual framework related to design technology for IGC systems. The conceptual framework provides a comprehensive overview of IGC systems in the innovation process by identifying five barrier dimensions and using six wellbeing determinants as IGC catalysts. Moreover, this study discusses future directions for research on IGC systems. This study offers a novel contribution by shifting the technology design process from an age-based design approach to wellbeing-driven IGC systems. Additional avenues for investigation were revealed through the analysis of the study's findings.

Keywords Intergenerational collaboration · Intergenerational innovation · Barriers and challenges · Digital collaboration · Startups innovation

1 Introduction

The prominence of the global issue concerning the aging workforce's wellbeing for intergenerational innovation has been stressed in several studies [1–4]. For instance, studies [5–8] noted that addressing intergenerational diversity management issues is critical to successful global organizations' startup innovation. Indeed, intergenerational issues have become one of the main concerns of today's workforce [8, 9], where the employees of a single organization can encompass up to four generations [4, 5]. We refer to intergenerational innovation as a group of adults from more than one generation collaborating in the creative process to explore and exploit valuable business ideas [7, 10]). The main objective of this paper seeks to understand the barriers, implications, and drivers of intergenerational innovation, especially concerning collaboration for global startups.

Although studies on the intergenerational context are still being debated [11, 12], the challenges are real [1, 6, 7, 13], notably how to shape positive interventions [14, 15] for the IGC [11]. While several studies on the Information Technology (IT) domain propose the incorporation of wellbeing as the driver to better IT design and to support collaborative innovation processes [15–17], a profound understanding of the barriers and how wellbeing can be embedded in intergenerational collaboration (IGC) systems design continues to be lacking [7]. Accordingly, the importance of a shift from age-based system design to a design that encompasses a broader range of ageless stereotypes has been highlighted in several studies [11, 12]. Therefore, we aim to address this study's underlying main research question: how to design a wellbeing-driven IGC system that supports the innovation process?

By examining the barriers to IGC and intergenerational innovation's associated wellbeing drivers, this study seeks to

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provide an overview and a foundation for a problem-based approach to system design. We conducted a thorough systematic literature review (SLR) [18, 19] and metadata analysis based on the study goals, which led to a conceptual model for designing intervention systems in the context of intergenerational innovation. The metadata and content analysis of SLR [18, 19] on IGC barriers enabled us to understand relevant sub-topics, different types of barriers, and strategies associated with technology-related wellbeing determinants in intergenerational innovation. To this end, we used the Positive Computing (PoCo) approach to emerging trends in human–computer interaction and IT design [14, 15].

As a reminder, the paper is structured as follows: the theoretical background; the methodological section, which covers data collection and analysis; the findings section, comprising barrier dimensions and the proposed determinants as the enabler of wellbeing for IGC; discussion; and finally, the conclusions and recommendations drawn from the research gaps.

2 Theoretical background

2.1 Intergenerational innovation

As the knowledge society grows, collaborating across continents and cultures becomes an essential requirement for international companies. A global economy and demographic shifts are also creating new ways to attract young talent from different countries to engage in collaboration and improve global innovation processes. Besides, senior innovators can benefit from young apprentices and actively participate in the global innovation process while improving personal wellbeing and social cohesion [7, 8, 23]. Regarding innovation processes, the IGC can strengthen exploitation and commercialization processes by creating new opportunities [24].

The grouping of generations in the workplace tends to be subjective [25]. However, based on Table 1, we started with the classification of generations based on age. It can help us determine which correlated differences, problems, and enablers were discussed in the literature together with generational differences. Following Loos et al. [26] and based on Table 1, we defined intergeneration in the digital age as: "interaction between different generations facilitated through digital media that has a greater likelihood of having disparate digital backgrounds and competencies due to (at least) 20 years age gaps." The number of age-year gaps is derived from the median age of the generations within a classification period (e.g., the median age of generation Y minus the median age of generation X). Therefore, as an entry point, we define younger adults as adults aged 18–30 years and senior adults as adults aged 50 years and older.

Table 1 Classification of Generations in IGC

Sources	Proposed Age-based Classification of Generation	Significance for this study
[20]	(a) Traditionalists: born between 1922 and 1946; (b) Baby Boomers: born between 1946 and 1964; (c) Generation X: born between 1964 and 1980; and (d) Generation Y: born between 1980 and 2000. This classification is mainly derived based on work–value differences for a given generation born within a given period	The paper presents an overview of age-based generational classification, which may be used to establish the number of years between generations with significantly different background experiences
[21]	(a) The modernists: before 2003 and (b) the postmodernists: born between 2003 and the present. This classification is based on the mindset of human power and authority	The study allows us to understand how differences in cultural environment can lead to differences in skills, competencies, and thinking patterns that shape particular generations
[22]	(a) Digital natives: educated digitally; (b) digital immigrants: born before the digital age and had to adapt; and (c) pre-digital immigrants: educated with a language other than digital and have often had to adapt to Information and Communication Technology (ICT) subsequently. The various main criteria for the classification of generations are related to digital literacy and digital experience	The study enables us to link generational differences in workplace behavior to divergent digital operational capabilities, technological design preferences, and preferred digital work platforms

Intergenerational innovation describes an intergenerational knowledge collaboration within the innovation process, where senior and younger adults can mutually share experiences and knowledge related to the innovation process or processes emerging from the conceptualization, design, or development, and commercialization. Such mutual knowledge exchange occurs in the exploitation of valuable ideas [7, 16]. On the one side, senior adults offer valuable resources for innovation training and mentoring for younger adults in a global environment. Conversely, barriers to intergenerational collaboration in digital learning seem to hamper collaboration [27, 28]. At this point, we begin with three main innovation processes to review the existing determinants of wellbeing and overcome the barriers to intergenerational collaboration in the innovation process.

2.2 Barrier dimensions of collaboration

Awareness of the IGC depends on age differences. Still, studies show that when conflicts occur, they are more likely to be due to differences in system interaction and operational styles as opposed to age differences [9, 29, 30]. Designing a system for the younger generation may cause the developers to lose the senior audience and vice versa. Age may not be a factor in the success of interaction and learning [9, 29], but rather a demotivating element in the use of technology for both generations [31]. For this study, we understand barriers as problems, challenges, gaps, or obstacles that can impede the achievement of a particular goal. Barriers in the intergenerational environment can demotivate the collaboration process. Several significant barriers have already been examined in other studies [7, 27, 28, 32, 33], including generational trust, lack of a supportive environment, lack of intergenerational collaboration competencies, and different generational characteristics.

For this study, we considered a classification of the barrier dimensions of Adams [34] and Litz [35] because they cover a wide range of barriers to the creative collaboration process [7, 34]. The first dimension relates to the intellectual dimension, which refers to barriers caused by information, expert beliefs, and style. The second dimension is the perceptual dimension caused by stereotyping—for example, the viewpoint toward others based on culture, gender, or physical characteristics. The third dimension is the emotional dimension, which arises mainly from embarrassment, discomfort, or fear of failure. The last is the cultural and environmental dimension, including external support and how to deal with a situation [34]. These classifications of barriers serve as a fundamental dimension for the IGC in the innovation process.

Based on the preliminary review in this section, it is crucial to understand the common barriers to IGC to develop IGC system requirements. Therefore, this study deals with the first guiding question of our research: "Which barriers (and dimensions) are involved in intergenerational collaboration?" The dimension of barriers to creative collaboration will be used as an initial classification that can be refined, extended, and modified based on the finding and the context of this study.

2.3 Positive computing approach

Calvo and Peters [14] introduced the concept of Positive Computing (PoCo). This concept promotes the determinants of wellbeing and boosts human potential through digital interaction. We employed the PoCo approach as we consider that the PoCo approach enables us to motivate senior adults to participate by entrusting them with meaningful activities (e.g., sharing experiences, wisdom, and appropriate marketing strategies). Secondly, to support younger users by exploring the potential to take full advantage of the wellbeing determinants and thus become more successful. The PoCo approach also requires the identification and consideration of barriers and challenges in technology design.

Furthermore, The PoCo approach goes beyond the user interface and encompasses the entire process of shaping the information society [15]. PoCo can influence the entire process of system design, from initialization and user study to development and evaluation [15]. Calvo and Peters [14] established three categories of determinants that can be used to promote wellbeing and, at the same time, can be translated into technological design interventions [14]:

- The first group of determinants is the self or the intrapersonal. In this group, the focus is primarily on design attributes that support the user's interaction with the system, including joy, interest in exploration and learning, pride in achievement, self-esteem, love, or the feeling of safety and close relationships. In this first group, the wellbeing-oriented technological interventions comprise uncomfortable activities that intersect with enjoyable interaction experiences;
- The second group of determinants pertains to the social or interpersonal designed to support users' social connectedness and the different social roles in the system. The determinants in this category include gratitude and empathy. Interventions include features that promote expressions of appreciation; communication features are designed to enable the expression of emotions through narratives and graphics;
- The last group of wellbeing determinants refers to the transcendental or extra-personal. It emphasizes the intervention for virtue or the focus on carrying out meaningful social actions. Calvo and Peters [14] classified compassion and altruism into this category. The variety of technological interventions available involves a design

for group empathy, technological features to mitigate guilt and judgment, and system development for inspiration that promotes the ability to translate empathy into action.

The integration of wellbeing into the design process of a system can be accomplished on four levels of implementation [14]: The first level is no integration of wellbeing. The second level is preventive implementation (removal of barriers). A third level is an active approach (use of wellbeing determinants as a driver for IT design). Finally, the design of a system aims to promote targeted technology-oriented determinants of wellbeing and human potential. This study concentrates principally on the second and third levels.

Overall, based on the PoCo approach, we postulate the second question for our review is: "Which wellbeing determinants are used to facilitate IGC in innovation processes?".

3 Methods

In this study, the positive computing approach has guided our research process of a systematic literature review or SLR [18, 19]. SLR was chosen as the main method for conceptualization to develop a concept based on a solid scientific basis [19].

3.1 Literature review and data collection

We performed a web-based automated search in digital libraries [18, 36] for IGC-based studies published in proposed scientific databases [36], including ACM Digital Library (ACM), IEEE Xplore (IEEE), Taylor and Francis Online (TnD), Science Direct (SD), and ISI Web of Sciences (WoS). The preliminary search for the deletion of duplicates revealed 281 out of 713 publications, and 75 publications were selected for analysis based on the SLR process and scope of the study [37]. The overview of the whole structured review process is outlined in Fig. 1.

We applied a set of keywords on 3 April 2020 to selected databases for articles published from the year 2000 and March-2020. The keywords for technology-specific databases (IEEE/ACM) searches were ("intergenerational") OR ("intergenerational" AND ["collaboration" OR "barrier"]) OR ("intergenerational" AND ["challenge" OR "problem" OR "GAP" OR "barrier" OR "obstacle"]). Moreover, for non-technology focused databases, we detailed the keywords for designing a digital technology to support IGC in the workspace ("intergenerational" AND ["digital" OR "computer" OR "technology"] AND ["gap" OR "barrier"] AND ["workspace" OR "workplace"]).

A publication was included as a source for the analytical review process if the proposed inclusion criteria were fulfilled [37]; likewise, a publication was removed from the reference list if the pre-defined exclusion criteria were found to be met. The inclusion and exclusion criteria are set out in Table 2. In selecting keywords, the term "intergenerational" already limited the number of articles. By including the term "Wellbeing" into the keywords selection, the results will be returned no selected articles. Therefore, in this phase, the term "Wellbeing" was not used but will be included in the second stage of analysis by combining different aspects of wellbeing determinants.

Initial result: 713 publications
IEEE: 78, ACM: 142, WoS: 33, SD: 80, TnD: 380

remove duplication ↓

Title and abstract evaluation: 281 publications
IEEE: 74, ACM: 68, WoS: 18, SD: 47, TnD: 74

exclusion criteria ↓

Fulltext evaluation: 156 publications
IEEE: 32, ACM: 46, WoS: 8, SD: 29, TnD: 41

inclusion criteria ↓

final selected publications: 75
IEEE: 22, ACM: 11, WoS: 8, SD: 14, TnD: 20

Fig. 1 The selection process of publications

3.2 Bibliometric analysis

Once a relevant literature set was identified for inclusion in the review, a bibliometric analysis was conducted based on the corpus of abstracts. The abstracts of the articles provide an overview of the research presented in the study and can therefore serve as a basis for identifying relevant terms and concepts that are commonly used for the study context beyond the keywords presented. Bibliometric analysis is a quantitative analysis tool to generate information about statistical metadata information to uncover emergence topics within a particular research area [38, 39]. One possible outcome of the bibliometric analysis is to list various terms and indicate the number of occurrences of each term (also with other terms to build the network between terms) in the collected data [39–41]. The correlation of the term with other terms can be determined to create a network visualization between the terms [40, 41]. Bibliometric analysis can be used to identify correlated terms based on the abstract to understand how research related to barriers to intergenerational innovation uses different terms in the knowledge corpus of this study context. Vosviewers software was used to conduct the bibliometric analysis, automatically provide cluster and weighting value of each term, and visualize the

Table 2 Criteria for inclusion and exclusion

Inclusion	Exclusion
Peer-reviewed journal or proceedings	Not written in English
Explicit citing of intergenerational terms in the abstract, title, or keywords	No explicitly stated barriers to IGC
Intergenerational collaboration in the context of the innovation process	No implications for younger and senior adults collaboration or in the global context

knowledge network [40, 41] based on the abstract of the included literature.

3.3 Literature analysis

The development of the conceptual model followed abductive thinking. Therefore, the best explanations for a particular concept were developed based on the selected articles' available observations. A single researcher conducted the coding procedure for content analysis to develop an initial conceptual model from the literature, following the epistemological approach of qualitative inquiry [42] and since a single researcher was used for the coding procedure in this study. Consequently, it is not necessary to perform inter-rater reliability for content classification validity in this study [43]. However, to achieve a robust result, a consensus approach was used. The initial conceptual model was presented and discussed with three other researchers with expertise in the study areas. All discrepancies in the initial conceptual model were reviewed and resolved until no further comments were received for significant changes to reach consensus among the researchers.

To provide a wellbeing-oriented design framework for the IGC, we used the concept matrix approach for literature review [19]. We synthesized the content of selected publications carefully, listed the identified barriers, and merged the redundant barriers based on their respective verbs and objects. Initially, we classified the barriers into four barrier dimensions based on the classification of Adams [34]. Those barriers that did not fit one of the defined classifications remained uncategorized. We coded and identified the similarity between uncategorized barriers until all the barriers were grouped based on the similarity of topics, objects, or verbs. The process was iterative until all barriers were carefully fit into one of the categories to the developed matrix of concepts (See Appendix Table 6).

The second stage of the analysis and review of the wellbeing factors led us to determine the type of collaboration activities, such as ideation, design, and development, or commercialization [10, 44]. Publications were grouped into collaborative and non-collaborative innovation activities. We analyzed 40 publications looking for three main activities in the innovation process (ideation, design and development, commercialization) of the collaborative innovation activities, using manual content analysis to find the determinants. We drew on keywords based on the wellbeing determinants of the PoCo approach and thoroughly read the selected papers to identify the relevant determinants. Accordingly, we identified the correlated wellbeing determinants of collaborative innovation processes [10, 44].

4 Result

4.1 Network visualization of relevant terms based on the abstract corpus

The bibliometric analysis results provide 59 terms clustered into six categories and provide visualization of the networking terms (Fig. 2). The first cluster has 22 terms or 37,28% of the identified notions, including [words (number of occurrences)]: benefit (7), characteristic (7), conflict (9), engineer (13), evidence (9), generation (55), generational difference (17), idea (10), knowledge (12), leadership (5), member (8), older worker (49), organization (9) outcome (10), problem (17), process (28), resource (5), solution (7), usefulness (5), work (9), worker (7), workplace (7). The first cluster shows the dominance of identified literature on the study context regarding intergenerational collaboration (for the terms: generational differences and generation) and collaborative innovation (for the terms: leadership, member, idea, knowledge, process, organization, workplace). Moreover, it also has relevancy regarding the term of problem and solution.

The second cluster consists of eighteen terms (30,51%) that can be described as technological experiences that mediate intergenerational collaboration; the terms included in this cluster are computer (7), experience (18), factor (14), family member (15), game (14), internet (12) medium (12), older person (8) past (5), population (11), project (15), service (16), sns (5), social interaction (6), social medium (5), system (17), use (16), and user (15). The third cluster consists of seven terms that focus on how to understand the technology accessibility of different roles: access (5), case study (5), family (27), programming (6), range (5), role (9), understanding (10).

The fourth cluster describes terms related to the teachers' types and forms: analysis (15), form (9), place (5), teacher (18), type (7), way (7). Moreover, the fifth clusters consist of five relevant to wellbeing and the background: mental health (6), migrant worker (8), the new generation (7), old

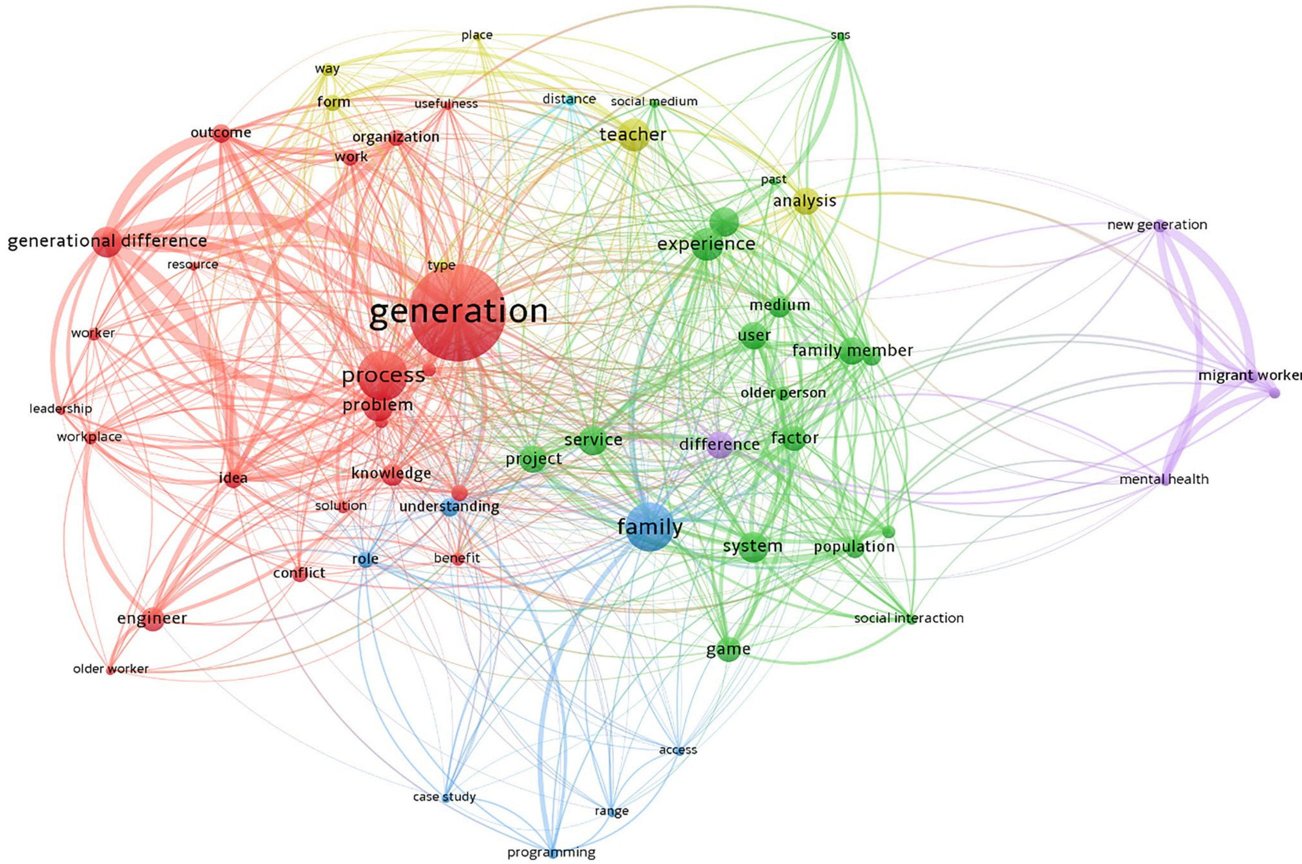

Fig. 2 Visualization network between identified terms in the study of intergenerational collaborations

generation (6). The last cluster has only the term "distance (6)".

4.2 Wellbeing-driven Framework for Intergenerational Innovation

The descriptive statistics of the collected papers (Fig. 3, right) show that researchers' interest in the correspondence barriers of the IGC has increased over the last five years. Given the origins of the studies, the global movement of the IGC study covers all continents except Africa (Asia: 13.7%; South America: 4.4%; Australia/Oceania: 8.6% Europe: 28.7%; North America: 38.4%; a collaboration between North America and Europe: 6.2%). The analysis of the study origins parallels the growing number of individuals in the aging population in both Europe and North America [45].

In terms of the sector in which the study was conducted (Fig. 3, left), the analysis of IGC-related barriers usually focuses on neutral industries (or can be conducted across industries). However, education and health care are the two dominant sectors where barriers to IGCs are prevalent. Interestingly, few studies seem to focus on banking, retail, hospitality, or government.

4.2.1 Barriers dimensions of intergenerational innovation

The conceptual mapping of barrier dimensions for intergenerational innovation comprises five dimensions. They include personal views (perceptual and emotional) and environmental views (cultural, institutional, technological dimension). Based on the conceptual matrix of Appendix Table 6, we present in Table 3 the five barrier dimensions of intergenerational innovation.

As a first step toward implementing a positive IT design for IGC, we identified five barrier dimensions covering a wide range of common challenges and difficulties faced dynamically by senior and younger adults in innovation activities [7, 33]. The barrier dimensions represent an important element in the implementation of the deductive approach of positive computing.

Emphatic/Perceptual barrier dimension. We defined the empathic dimension as the negative viewpoint of a generation toward different generations. This strong negative viewpoint hinders IGC because of someone's experience in the past. Barriers related to perceptions of others include age discrimination [46, 57, 58], a different mindset [32, 58] and interests [59, 60], and generational resistance [27, 46, 58].

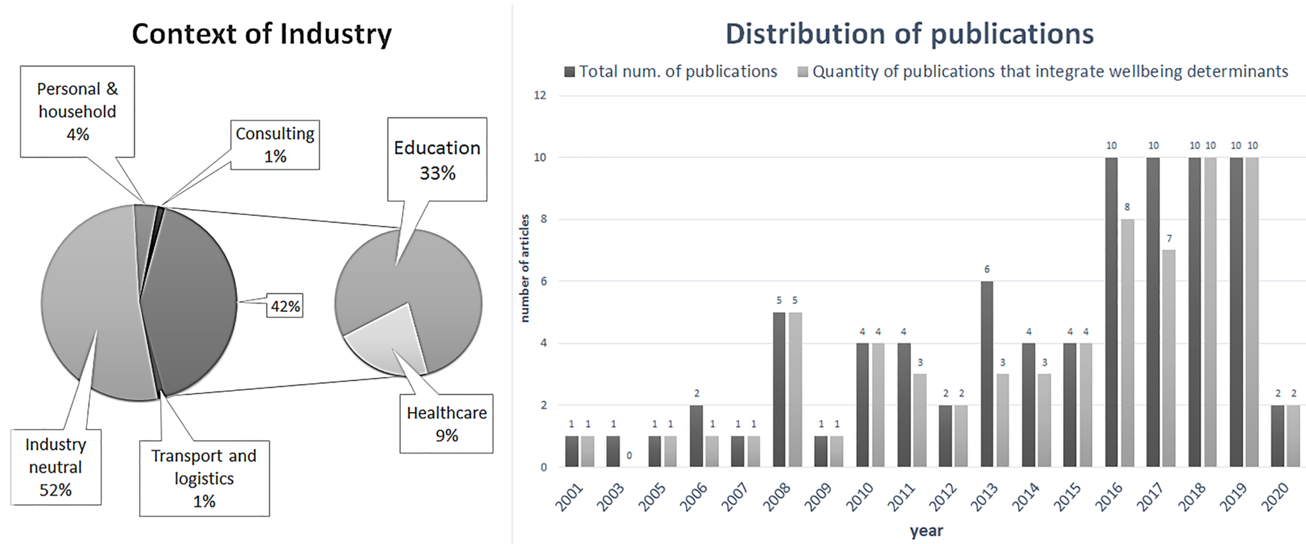

Fig. 3 Mapping the IGC publications

Table 3 Barrier dimensions of intergenerational innovation

Dimension	Explanation	Example of references
Perceptual barriers	Barrier dimension concerning the way someone perceives others. Negative viewpoints of a generation toward different generations	[32, 46–49]
Emotional barriers	Associated with a negative self-view or egocentricity. These barriers are related to how people understand themselves	[6, 50, 51]
Cultural barriers	Denotes external environmental barriers that focus on informal codes and standards	[9, 48, 52]
Institutional barriers	Imposing barriers from the external that elaborate organized or formal rules and requirements	[9, 51, 53]
Technological and Operational barriers	Barriers associated with technology and operational use	[54–56]

Moreover, a lack of understanding of IGC [29, 61], a lack of awareness of differences between generations [27, 32, 62], a lack of empathy [47, 58], building interpersonal trust [32, 63] and a lack of respect [47, 58] are challenging to cross-generational collaboration.

Emotional barrier dimension. The emotional dimension is a collection of barriers associated with feelings and a negative self-view or egocentricity. These barriers are related to how one generation conceives of working with another generation. Barriers in this category are feeling underappreciated or unappreciated [32, 58, 59] and lack of self-confidence, and the feeling of reacting too slowly [47, 64]. Fear of technology [59, 61, 65], functional limitations [46, 61, 66], lack of motivation [61] and feeling isolated [46] are barriers related to the emotional dimension.

Cultural barrier dimension. The cultural dimension represents external environment-related barriers that concern informal codes and norms. One of the main issues of global collaboration is the substantial differences in cultural traditions compared to other generations [59, 67]. Barriers also arise in this category because people are unaware that they can work with culturally different people [66, 68]. Furthermore, other barriers in this dimension that can hinder IGC are a lack of social support [32, 59, 67] and a lack of sensitivity to technological design that interferes with the cultural background of a particular generation [13, 66].

Institutional barrier dimension. The institutional dimension is defined as administrative barriers that focus on organized rules and requirements, including barriers to shared resources [13, 66, 78], geographical distance [78] between cooperation partners, and high market uncertainty in product markets [8, 56, 68] for innovation partnerships. Data protection issues [63] and differences in educational levels [46, 59, 63] can complicate technology-mediated intergenerational collaborative innovation.

Technological and operational barrier dimension. The technological and operational dimension covers barriers related to knowledge and resources regarding technology and operational use. Barriers in this category include lack of independence [54, 72, 79], the high cost of technology investment [46, 59, 63], the complexity of virtual presence management [63, 65], and generational differences in technological backgrounds [47, 52, 59, 63, 67, 69]. Other barriers are lack of joyful activities [54, 59, 69, 80] that can be integrated into real-life collaboration [46, 50], the lack of technical training for digital collaboration [63], insufficient technological access [52, 63, 69] without a supportive technological environment [52, 55, 56, 69, 81], and the complexity of technology [56, 65, 82]. In some cases, the collaboration between the two generations could also be challenging because there is no right time for an appointment [21, 32, 83]. The differences in routine patterns are unclear [13, 35, 78].

4.2.2 Wellbeing determinants of intergenerational innovation

The selected publications may not have explicitly mentioned the type of collaborative IGC innovation activities. Some publications dealt with more general collaborative innovation activities [8, 13, 35, 60, 68], including exploration (ideation and design and development) and commercialization or market exploitation [13, 44, 56, 84]. Even though the IGC potentially boosts innovation, we identified only three publications [8, 56, 68] highlighting IGC-related barriers that promote collaboration in commercial activities. Table 4 shows the wellbeing determinants as enablers of IGC identified from the literature.

Positive emotions of joy and playfulness in intergenerational knowledge exchanges. These positive emotions are feelings or forms of expression linked to the emotional experience of joy incorporated into the IGC. The experience of joy should be perceived when using an IGC system. The determinant has been identified in the design and development, and exploration. The types of interventions involved in enjoyment are the use of hybrid technology by combining the physical and digital spheres in a collaborative activity, the use of persuasive technology, and location-based gamification [52, 56, 69, 70].

Positive emotions of interest in and exploration of a problem-based learning scenario. Such feelings or expressions are related to the emotional curiosity acquired in learning integrated into the IGC. These feelings frequently emerge in unforeseeable scenarios. Twenty contributions pointed to the user's interest and exploration of the IGC system design. The determinant has been identified within the following IGC activities: ideation, design and development, and exploration. Competence development programs through hackathons [73] or using blended learning for IGC were integrated to foster the interests of the collaborators of IGC. Guidance on technological use, integration of hub agents, and gamification via assisting systems or robots can also be employed [33, 50, 51, 71].

Positive emotions of pride and achievement of collective goals. Such feelings or expressions are associated with the emotional experience of accomplishing purposeful goals, such as achieving a list. These types of emotions do exist in the exploration. The types of interventions encountered in the literature are social presence digitalization and implementation of persuasion technology [33, 35, 72–74].

The positive emotion of competence-based contentment and self-views. It is an emotion or expression associated with the experiencing of high certainty and minimal effort based on self-reflection. These emotions can be found in the IGC innovation activities of idea generation and exploration. The types of interventions in the literature are attributes that support the exchange and building of competencies for the IGC, the use of interactive storytelling, and scheduled IGC evaluation and assessment programs [8, 9, 30, 33, 69, 75];

Motivation and Engagement (ME). Motivation and engagement for the IGC community represent a flow of personal experience or the momentary state of affairs that

Table 4 Wellbeing determinants as an enabler for intergenerational innovation

Determinants	Explanation	Example of references
Joy and playfulness	Positive emotions (joy/playfulness) are feelings or expressions related to the emotional experience of pleasure that is integrated into IGC	[52, 56, 69, 70]
Interest and exploration	Positive emotions (interest/explore) are feelings or expressions related to the emotional experience of curiosity that is integrated into IGC	[50, 51, 71]
Pride and achievement	Positive emotions (pride/achievements) are feelings or expressions related to the emotional experience of achieving meaningful goals	[35, 72–74]
Competency-based contentment and self-views	Positive emotions (contentment/self-views) are feelings or expressions related to the emotional experience of high certainty and low effort based on self-evaluation on competency development	[8, 9, 30, 69, 75]
Motivation and engagement	Motivation and engagement are the flow of experiences or the momentary condition that balance between task and competence	[55, 69, 70, 76]
Apprenticeship-based social relatedness	Apprenticeship is "concerns the act of 'helping others." It provides functionality that can support social interaction and actualization to help others	[50, 51, 69, 71, 75, 77]

creates a balance between challenges and competence as well as stimulating eagerness, self-responsibility, and ownership. ME was found the following ICG innovation activities: ideation, design and development, and exploration/commercialization. Gamification, persuasive technology, self-assessment and evaluation instruments, competence acquisition through role-playing, and intergenerational community building can be applied to support ME [33, 55, 69, 70, 76].

Apprenticeship-based social relatedness (empathy, compassion, altruism). The determinant deals with the act of helping others. It presents functionality to support social interaction and self-actualization to assist in helping others. Mentorship and camaraderie are good examples of the relatedness found in the IGC innovation activity of exploration. Some publications related the wellbeing determinant of "relatedness" to ME in ideation and exploration. The purpose of the determinants for the IGC is to strengthen the interpersonal and professional ties between younger and senior adults through persuasive technologies for the co-development of innovative products, hybrid/blended learning, and location-based game, a workshop for competence development, digitize social presence, and interaction [33, 50, 51, 69, 71, 75, 77]

5 Discussion

In this study, through the process of SLR, we combined bibliometric analysis with a two-step literature analysis. Correlation between different terms related to intergenerational collaboration was identified. Detailed barriers and wellbeing-based solutions were presented. Based on the bibliometric analysis, we discussed several correlated important terms that were found from the selected literature. First, our study shows that problems in intergenerational collaboration are complex and multifaced. To support the previous study [9], the problems in intergenerational collaboration can occur in the workplace, and organizational context, but also in the family context regarding different experiences of technological used [37, 59, 85]. There is also relevance to take attention to the leadership skill for intergenerational collaboration, different accessibility, and importance to discuss what are the expected outcomes of intergenerational collaborations. The filtered visualization of the network of problems can be seen in Fig. 4.

Second, when filtering the visualization network by the term "solution" (presented in Fig. 5), the study results show that the number of occurrences is smaller than that of the term "problem," which means that it is important to investigate the problems before exploring relevant solutions for intergenerational collaboration. Some terms that correlated directly with the terms "problem" also correlated directly with the "solution," such as leadership, workplace, process, work, outcome, and terms related to the second cluster or technological experiences (user, factor, and computer). In the visual networking of terms, the terms "games" were also mentioned, showing the potential for gamification of tasks supported by digital technology within innovations in intergenerational settings. Furthermore, there is no direct link from "solution" to the term "mental health," which is known to be negatively associated with wellbeing [14]. However, in this study, a two-step literature review was conducted to gain a deeper understanding beyond numbers and bibliographic analysis of competing concerns and the role of wellbeing determinants that have been used but little recognized.

The mapping of barriers and correlated wellbeing determinants contributes to developing a conceptual framework for the positive design of the IGC in the context of innovation activities as part of the preventive approach of PoCo (Calvo and Peters 2014). To mitigate the factors that are hampering the IGC's interaction with technology, we identified five-dimensional barriers. These barrier dimensions may generally be applied to collaboration in a global context, as the barriers were identified from different continents and cover the cultural dimension.

As for the theoretical contributions of the study, compared to previous dimensions [34, 35]regarding the IGC, the barrier dimensions underpin the current study on barriers to intergenerational innovation, which includes specific dimensions for technological and operational skills [7, 13]. Such barrier dimensions also embody the nature of technology-mediated IGC and the challenges faced by generations regarding technological interaction.

Regarding barriers in the PoCo framework, Calvo and Peters [14] suggested that gratitude and empathy could help to combine interpersonal aspects and technological attributes. We found empathy, compassion, and altruism (ECA) associated with collaborative innovation activities as opposed to gratitude. ECA is commonly linked with relatedness or social connectedness [14]. Therefore, we propose relatedness as the wellbeing goal of IGC (as the dedicated approach to IGC design oriented toward wellbeing). Barrier dimensions of the IGC relating to empathy and perception can be addressed through the use of robots, chatbots, or digital mediators, which can facilitate collaboration and potentially alleviate negative sentiments and difficulties in communication and mutual understanding [86, 87]. Apparently, as one of the strongest predictors of wellbeing, gratitude [88] appears to be missing from the literature. It can be an alternative determinant of wellbeing in a dedicated approach to designing IGC systems. The supportive relationship can be used in synchronous and asynchronous IGC communication channels in the context of mutual learning [67, 74, 85].

Furthermore, the IGC design can be shaped to support coping skills to transform empathy into actions that can deal with judgment and guilt [14]. Role-playing between

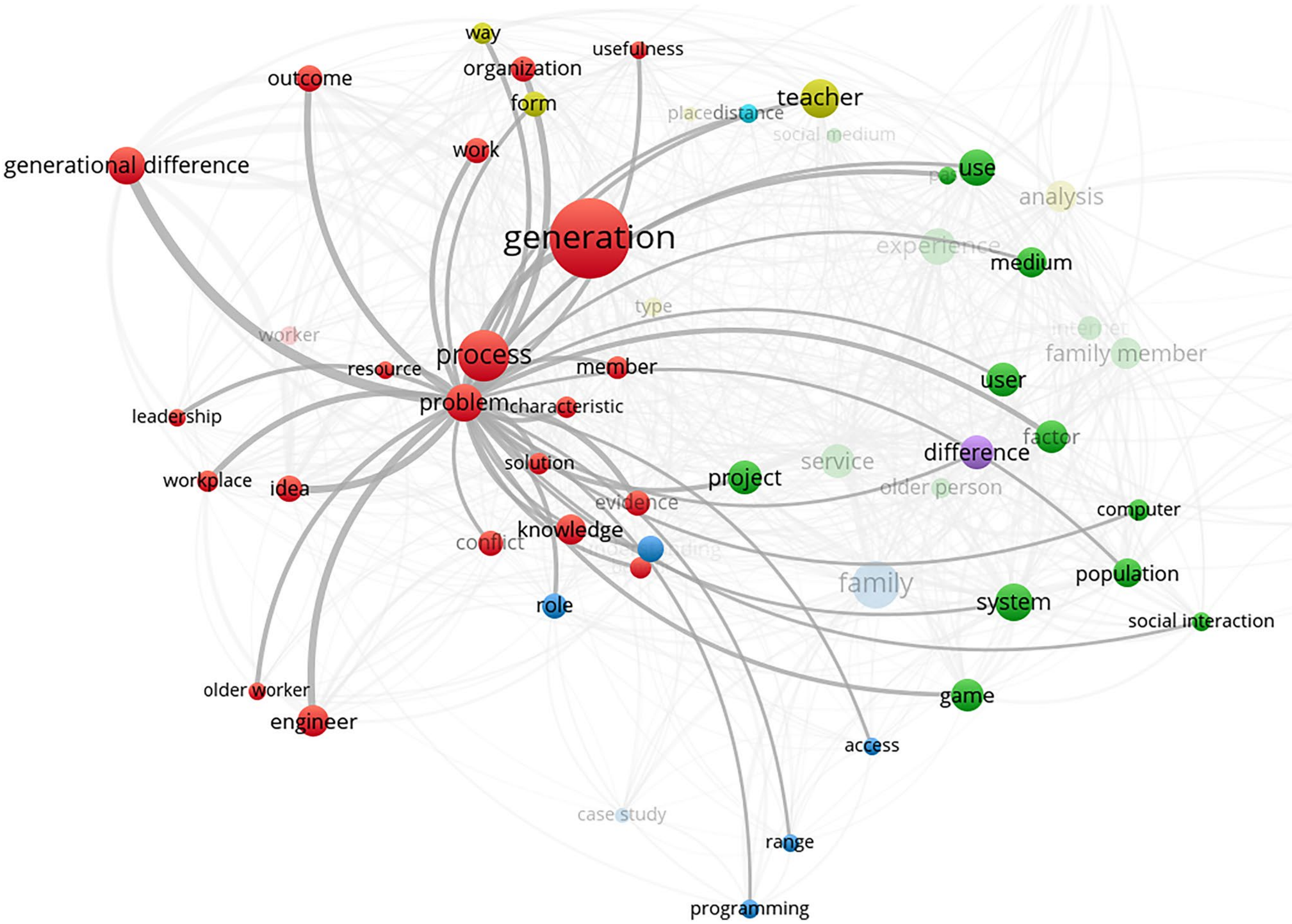

Fig. 4 Network visualization of the term "problem" in the literature on intergenerational collaboration

generations in localized community-based activities [2, 72, 74, 87, 89] could strengthen the emotional bonds and empathy among collaborators and tackle the dimensions of cultural and perceptual barriers.

We also found that compared to other wellbeing determinants without including the positive emotion that consists of three sub-categories, motivation and engagement focus on IGC publications (occurring in 20.3% of selected papers, based on Appendix Table 6. Therefore, system designers of IGCs should be aware of interventions that address motivation and engagement. Moreover, setting a common meaningful goal, empowering creativity, and eliciting appropriate feedback through virtual goods to motivate [90] both the senior and younger adults is important.

We were not able to identify any papers in which "positive emotion" was explicitly mentioned. Instead, we noticed that joy and interest were referred to in 16.2%, interest and exploration: 27%, pride, and achievement: 4% selected publications as enablers for IGC. Therefore, we considered joy, interest, and exploration as determinants of wellbeing to support the IGC design and recommended positive emotions as a critical factor of wellbeing in the active approach of the PoCo. Additionally, the experience flow may be combined with positive emotions to accommodate fun and enjoyable activities such as serious games or gamification [35, 74, 87, 89].

Obviously, cultural, institutional, technical, and operational barriers to the system design are common [7, 19, 91] and emerge in the IGC system. We consider pride and contentment to be one of the alternative determinants of an active approach to wellbeing-driven system design [14]. Although these are two elements of positive emotions, they were rarely discussed. Nevertheless, pride or achievement might serve in the exploration process. For instance, system designers could use a progress bar to set action rewards, a ranking, and badges to promote satisfaction and pride [90].

Concerning institutional barriers, the IGC system designer can use the determinant pride or accomplishment to integrate the competency-based self-assessment system into the matching process of the IGC system. IGC collaborators can evaluate and self-reflect their skills development and performance [79], which may overcome barriers,

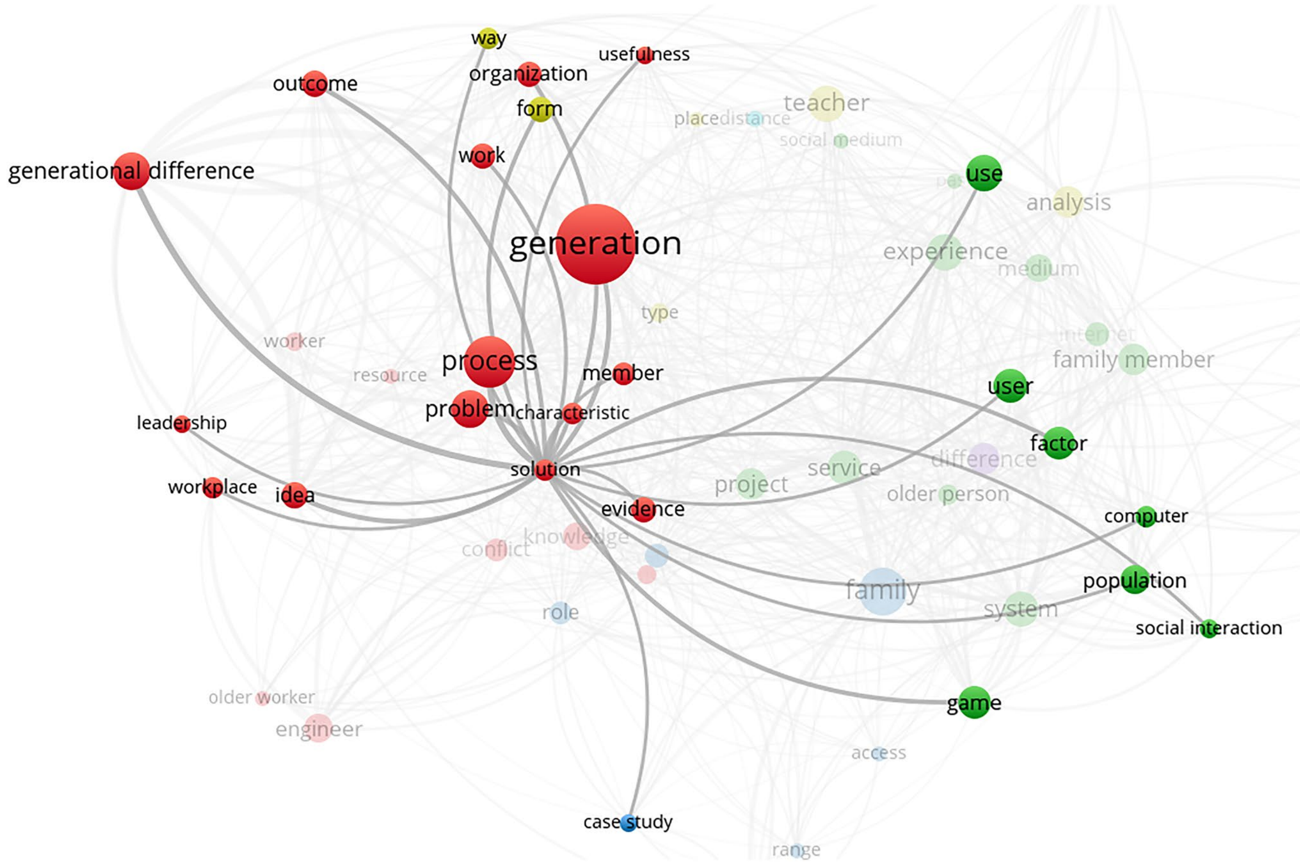

Fig. 5 Network visualization of the term "solution" in the literature on intergenerational collaboration

particularly in the institutional dimension. The self-assessment system can automatically match collaborators or help identify the right person with whom to collaborate. A hybrid technology [52, 53, 92] combining tangible and intangible technologies also leads to developing a system that can be customized according to the user's physical and cognitive abilities and preferences.

Overall, in terms of knowledge contribution, the outcome of this study, by providing targeted determinants of wellbeing, confirmed the previous study in focusing on activities, roles, goals, or motivation to promote intergenerational collaboration [93], rather than focusing on age stereotypes [12].

For practical contributions, the proposed conceptual framework can be used as a basis for the development of IGC system requirements, as a reference for system designers or developers in the development and prioritization of system design principles. The proposed barriers and enablers of an IGC system can also be used as an assessment tool or to evaluate an existing system that is to be used to support intergenerational collaboration.

Moreover, system designers can use the framework to identify the appropriate design principles by targeting specific wellbeing determinants for the IGC context. Also, system designers can prioritize particular barriers and enablers to design technology for the IGC setting. For IT designers with a strong background in developing applicable interventions based on the Design Science Research Methodology, the barriers can be used as an entry point for the research design process of problem identification or research entry points for objective solutions [94]) for positive design interventions [15]. Also, for IT designers who focus on human-centered design [91], the dimensions of the barriers, as well as the wellbeing determinants, can be used to develop user personas [91] and set the proposed wellbeing determinants as part of the goal or motivation for the IGC personas [7].

6 Conclusion, limitations, and recommendations

In conclusion, subsequent to the analysis conducted to address the primary research question, we elaborated an overview (Fig. 6) on designing a wellbeing-driven IGC system. The overview emphasizes the positive design of

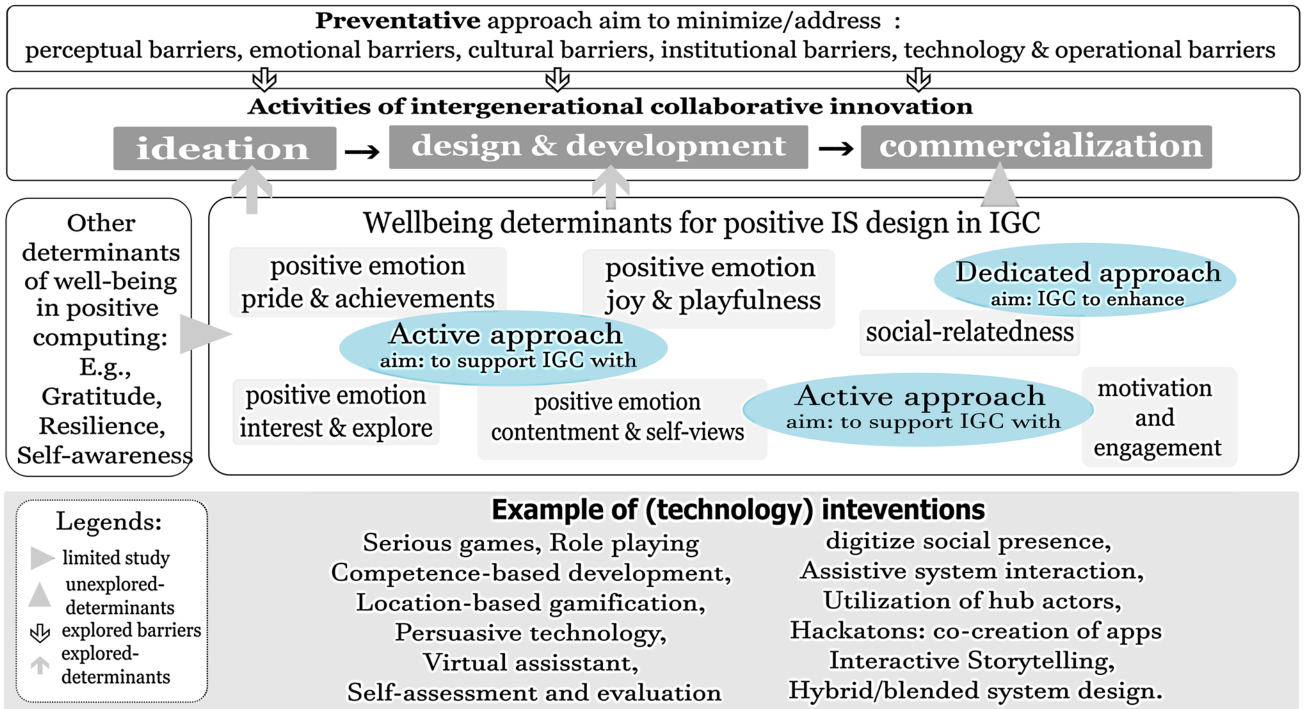

Fig. 6 Wellbeing-oriented IT design for IGC

IGC in innovation activities by incorporating various types of technological interventions.

To promote a wellbeing-driven system for IGC, the system can be initiated by integrating five dimensions of barriers, the correlated wellbeing determinants, and implementing preventive (to remove the barriers), dedicated (to improve social relatedness between generations), or active approaches (to support innovation activities with design for positive emotions including achievements, contentments, self-views, interest and exploration; and design for motivation and engagement) according to the PoCo level of implementation. To achieve the positive design for the IGC system, system designers can utilize, for instance, the gamification approach, competency-based collaboration in hybrid digital environments.

Moreover, several limitations are also presented in this study for further analysis 1) Different keywords were applied; however, subjective opinion is nature in the search effort, particularly selecting the keywords. Keyword selection can affect search results. It is essential to determine whether keywords produced the best results. Some associated keywords may be missing;

2) We only performed web-based automatic literature searches. Databases selected may contain important journals that were not included in the selected literature. However, we have carefully conducted the selection process. A manual search was also performed, and relevant where recommended IGC journals from IGC scholars and experts could be included;

3) Lack of thorough location-based barrier analysis to identify barriers relevant to specific continents could be used to design a global IGC system. Therefore, our study's limitations also represent an opportunity for further research to support the IGC innovation process.

The findings suggest that motivation, engagement, and positive emotions (interest and pleasure) play an integral role in the IGC. As far as motivation and engagement are concerned, specific competencies are required for assignments within the innovation activities, e.g., problem-solving and creative thinking. We noted that the IGC is a global issue and increasingly attracts researchers interest in all continents, which can be useful in many areas, particularly in the education and training industry. We expect that further studies on the technology-mediated IGC will open up new opportunities to assess and elaborate on the proposed framework. Therefore, in Table 5, we provide a set of questions that need to be addressed to close the gaps in recent IGC studies, allowing researchers to modify these questions to better suit particular research problems.

Table 5 Proposed research questions for further studies

Proposed questions	
Topic related to IGC Barriers	How does the barrier framework affect the choice of technology and approaches in intergenerational system design?How do both generations perceive the level of barriers to collaborative innovation? What barriers do both generations believe will have the greatest impact on each of the more specific collaborative innovation processes? How do the dimensions of the barriers change dynamically in the innovation process? Which barriers should be given priority in the development of specific technologies for the IGC? How can age differences be incorporated into the system, which focuses on the barrier dimension of the IGC?How does the dimension of the barriers of the IGG manifest itself in different industrial sectors, especially in public institutions?
Topic related to Method	How can a well-being-oriented design approach to an IGC system be evaluated? How can we better design a social inclusion system that takes into account the preferences of both younger and senior adults? How can the participation of both generations in designing a support system for the IGC on global innovation be facilitated?
Topic related to Wellbeing determinants as IGC enablers	Which wellbeing determinants of PoCo can promote IGC in the commercialization process? How and what type of competencies (human potential) in the global innovation process can be supported by the dedicated design approach of IGC? Why are particular wellbeing factors superiors compared to other determinants to support the IGC? Which personal, social, and organizational factors contribute to the better impact of the wellbeing determinants? How can the determinants of wellbeing be integrated into more detailed innovation activities?Which design principles based on the wellbeing determinants are suitable for the IGC?How can technology be designed to promote gratitude in the IGC?

Appendix

See Table 6**Table 6** Concept matrix of IGC studies

Reference	Barriers					Wellbeing determinants					
	PB	EB	CB	IB	TB	JP	IE	PA	CS	ME	AR
[95]			x		x						
[52]			x		x	x	x			x	
[46]	x	x			x						
[61]	x	x			x						
[96]					x						
[69]					x	x	x		X	x	x
[97]	x	x		x							
[98]	x			x							
[50]		x		x	x	x	x				x
[59]	x	x	x	x	x						
[65]	x	x			x						
[99]	x		x								
[47]	x	x			x		x			x	
[100]				x							
[67]			x	x	x	x	x			x	
[48]	x	x	x	x					X		
[53]		x	x	x		x			X	x	
[63]	x			x	x						
[32]	x	x	x		x						
[101]	x		x								
[55]	x			x	x				X	x	
[51]	x	x	x	x			x				x
[71]					x		x		X		x
[102]	x										
[49]	x				x		x				
[82]			x								
[6]	x	x			x					x	x
[20]	x						x				
[60]	x						x				x
[103]					x						
[86]					x		x		X		
[104]		x		x	x						
[105]			x	x	x						
[72]	x					x		x	X	x	
[79]		x				x	x			x	
[56]	x		x		x						
[73]	x	x			x		x	x			
[106]	x	x	x		x		x				
[92]				x	x		x			x	
[81]				x							
[29]	x				x						
[31]		x			x						
[57]	x	x			x						
[107]					x						
[35]					x	x	x	x			
[108]	x		x								

Reference	Barriers					Wellbeing determinants					
	PB	EB	CB	IB	TB	JP	IE	PA	CS	ME	AR
[74]	x					x		x		x	x
[23]			x		x				X		
[80]	x	x			x						
[64]		x			x						
[68]			x	x							
[78]				x	x						
[66]		x	x	x							
[13]	x	x	x	x	x		x				
[75]	x			x	x				X		x
[62]	x										
[109]		x	x	x	x						
[9]	x	x	x	x					X		
[83]					x						
[30]			x	x					X		
[77]	x		x						X		x
[70]	x					x				x	
[110]			x	x							
[58]	x	x			x						
[8]			x	x					X		x
[87]	x		x			x	x			x	
[111]	x										
[112]			x		x						
[113]	x		x								
[114]				x	x						
[76]	x		x	x							
[89]				x		x	x			x	
[115]	x				x						
[85]					x		x			x	
[21]	x				x						

PB Perceptual barriers dimension, *EB* Emotional barriers dimension, *CB* Cultural barriers dimension, *IB* Institutional barriers dimension, *TB* Technological and Operational barriers dimension, *JP* Joy and playfullness, *IE* Interest and exploration, *PA* Pride and Achievement, *CS* Competency-based contentment, *ME* Motivation & Engagement, *AR* Apprentincehsip-based Social relatedness.

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Declarations

Conflict of interest The author declare that they have no conflict of interest.

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