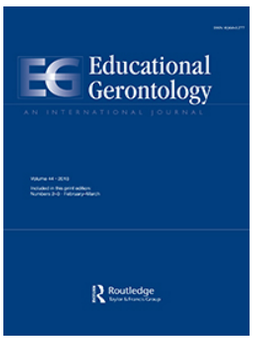

Educational Gerontology

ISSN: 0360-1277 (Print) 1521-0472 (Online) Journal homepage: http://www.tandfonline.com/loi/uedg20

Exercising older people´s brains in Costa Rica: Design principles for using information and communication technologies for cognitive activity and social interaction

María Dolores Castro Rojas, Ann Bygholm & Tia G.B Hansen

To cite this article: María Dolores Castro Rojas, Ann Bygholm & Tia G.B Hansen (2018) Exercising older people´s brains in Costa Rica: Design principles for using information and communication technologies for cognitive activity and social interaction, Educational Gerontology, 44:2-3, 171-185, DOI: 10.1080/03601277.2018.1433485

To link to this article: https://doi.org/10.1080/03601277.2018.1433485

Accepted author version posted online: 29 Jan 2018.
Published online: 29 Jan 2018.

EDUCATIONAL GERONTOLOGY
2018, VOL. 44, NOS. 2–3, 171–185
https://doi.org/10.1080/03601277.2018.1433485

Routledge
Taylor & Francis Group

Exercising older people´s brains in Costa Rica: Design principles for using information and communication technologies for cognitive activity and social interaction

María Dolores Castro Rojas[a,b], Ann Bygholm[a], and Tia G.B Hansen[b]

[a]e-LearningLab, Center for User Driven Innovation, Learning and Design, Aalborg University, Aalborg, Denmark; [b]Center for Developmental & Applied Psychological Science (CeDAPS), Department of Communication and Psychology, Aalborg University, Aalborg, Denmark

ABSTRACT

This study is part of a design-based research project aimed at designing a learning intervention for enabling Costa Rican older people to use information and communication technologies for cognitive activity and social interaction. Data from relevant literature, a focus group with older adults, and interviews with professionals teaching older adults how to use information and communication technologies were analyzed, in order to create context-sensitive design principles that could guide the design of learning interventions that meet the needs of older learners. The analysis derived context-sensitive design principles that include wider topics that influence the learning process, such as emotions and stereotypes related to learning about and using information and communication technologies, as well as the social support to that learning. The resulting eight design principles argue for respectful learning environments, in-depth comprehension of changes related to aging, time and space to reflect on emotions related to the learning process, and acknowledgment of participants' individuality.

Introduction

Cognitive functioning is one of the most important and decisive factors in relation to successful and active aging, due to its relationship with the instrumental activities of daily living, independence, and social interaction (Hultsch, Hertzog, Small, & Dixon, 1999; Plehn, Marcopulos, & Mclain, 2004; Schooler & Mulatu, 2001; Smith & Kosslyn, 2014). It is also well known that social engagement is associated with successful and active aging processes (Baltes & Baltes, 1990; Rowe & Kahn, 1997; World Health Organization [WHO], 2002), while social isolation and loneliness in old age have been linked to a decline in both physical and mental wellbeing (WHO, 2002).

In the "normal" aging process (in contrast to pathological processes), there is generalized cognitive decline, which is more marked in tasks associated with abilities such as working memory, reasoning, and rapid processing of information (Baltes & Baltes, 1990; Buckner, 2004; Castro, 2012; Fernández-Ballesteros, 2008; Fernández-Ballesteros, Molina, Schettini, & Del Rey, 2012; Fernández Ballesteros, García Rodríguez, & Caprara, 2005; Lowe & Rabbitt, 2005; Schaie, 2005b; WHO, 2002). However, there are individual differences in cognitive performance among older adults, and there is no uniform pattern of age-related changes across cognitive abilities (Baltes & Baltes, 1990; Buckner, 2004; Lowe & Rabbitt, 2005; Rowe & Kahn, 1997; Schaie, 2005a; Thompson & Foth, 2005). In addition, cognitive decline can be offset through strategies such as

CONTACT María Dolores Castro Rojas mariacastro@hum.aau.dk Department of Communication and Psychology, Aalborg University, Rendsburggade 14, Aalborg, 9000, Denmark

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/uedg.

participation in social and educational activities, and training processes that enable cognitive activity (Anguera et al., 2013; Baltes & Baltes, 1990; Fernández-Ballesteros, 2008; Fernández-Ballesteros et al., 2012; Fernández Ballesteros et al., 2005; Hultsch et al., 1999; Rebok et al., 2014; Rowe & Kahn, 1997; Willis, Tennstedt, & Marsiske et al., 2006; WHO, 2002). Furthermore, it has been observed that older people who engage in cognitive leisure activities and those who participate in formal educational activities have better cognitive performance than those who do not engage in such activities (Bosma et al., 2002; Castro, 2012; Hertzog, Kramer, Wilson, & Lindenberger, 2009; Hultsch et al., 1999; Rebok et al., 2014; Schooler & Mulatu, 2001; Stern, 2009; Wang, Xu, & Pei, 2012; Wilson et al., 2013).

Today, aging is accompanied by changes in roles within social structures, the migration of young people seeking work, the smaller size of families, and the prevalence of working women, leading to a lack of people available for socially interacting with or taking care of older people (WHO, 2015). This could have negative implications, particularly bearing in mind that a positive and robust social environment plays a role in protecting against cognitive decline (Baltes & Baltes, 1990; Rowe & Kahn, 1997; Seeman, Lusignolo, Albert, & Berkman, 2001; WHO, 2002).

Older adults can benefit from using Information and Communication Technologies (ICTs) for forming new friendships, accessing information, and participating in learning activities and specific cognitive training (Ala-Mutka, Malanowski, Punie, & Cabrera, 2008; Charness & Boot, 2009; Czaja et al., 2006; Czaja & Sharit, 2012; Sayago, Forbes, & Blat, 2013; Vroman, Arthanat, & Lysack, 2015).

Despite the potential of ICTs to improve quality of life during old age, older people often do not use ICTs tools. By 2016, only 45% of people aged between 65 and 74 and living in the European Union were using the Internet frequently (every day or almost every day) (European Commission, 2017). In 2011, in Costa Rica, only 14% of people in that age group were using the Internet (Instituto Nacional de Estadística y Censos [INEC], 2012), but there was little information concerning how they were using ICTs. Castro, Bygholm, and Hansen (2016) reported that their participants in Costa Rica mainly used the Internet for social networking and stated that increasing the number of older people benefit from ICTs and promoting the use ICTs for performing instrumental tasks, sharing through groups and communities, and learning for personal development were challenges that still needed to be overcome. The most frequently cited barriers to learning about and using ICTs were lack of suitable learning opportunities and inadequate learning environments.

In this regard, it is known that older adult's motivations to learn rest on their perceptions of how useful the learning will be and of their capabilities to achieve the relevant learning results. Therefore, learning interventions using ICTs should be made more readily available to older people and be easily accessible in terms of both physical location and content. Learning interventions using ICTs should consider different levels of learning needs, as well as devices and software applications that are relevant for older people (Ala-Mutka et al., 2008). Thus, the challenge is to design suitable learning interventions to facilitate the use of ICTs for cognitive activity and social interaction that include activities that are readily accessible, affordable, and enjoyable for older adults (Ala-Mutka et al., 2008; Charness & Boot, 2009; Thompson & Foth, 2005).

Design-Based Research (DBR) allows for the design of learning interventions based on collaboration among researchers, participants, and practitioners in real-world settings. Based on the inputs from theory and analysis of the problem with participants and practitioners, design principles are developed to guide the design of a learning solution that must then be implemented, tested, and refined in practice. Finally, refined, contextually-sensitive design principles are produced, as well as theories that can be applied to broader contexts (Reeves, 2006; Wang & Hannafin, 2005).

Implementing Coto´s (2010) DBR approach, we collected inputs from the scientific literature, participants (ICT older learners), and practitioners (ICT teachers) and developed a set of design

principles for guiding the design of learning interventions to enable older people to use ICTs for cognitive activity and social interaction.

Material and methods

General design

The study implemented Coto's (2010) DBR approach, which includes five phases: 1) analysis of practical problems by researchers, practitioners, and participants; 2) development of solutions within a theoretical framework; 3) evaluation of solutions in practice; 4) documentation and reflection to produce final "design principles"; and 5) dissemination.

Phase 1 was partially implemented in our previous work (see Castro et al., 2016), and this paper presents complementary information from older learners and teachers regarding how to design suitable learning opportunities to enable older people to use ICT for cognitive activity and social interaction. We also provide information about phase 2 by presenting the theoretical framework of the design process and the design principles derived by combining inputs from theory, learners, and teachers.

Methods and participants

The context and the participants of the general project were described in an earlier paper by Castro et al. (2016). Here we report the findings from a literature review, a focus group interview with learners, and two interviews with teachers. We reviewed the scientific literature on active aging and ICTs, cognitive abilities and ICTs, social interaction and ICTs, and older adults and ICT learning. After reading the literature, common themes were identified and synthesized.

A focus group was conducted with seven project participants. They were ICT users and non-users: three (two female, one male) used several ICT devices and applications more than once a week and were high school graduates or had some university education; one (male) used some ICT applications more than once a month and had some university education; one (female) used some ICT applications more than once a month and had primary school education; and two (female) did not use ICTs and had primary school or some high school education.

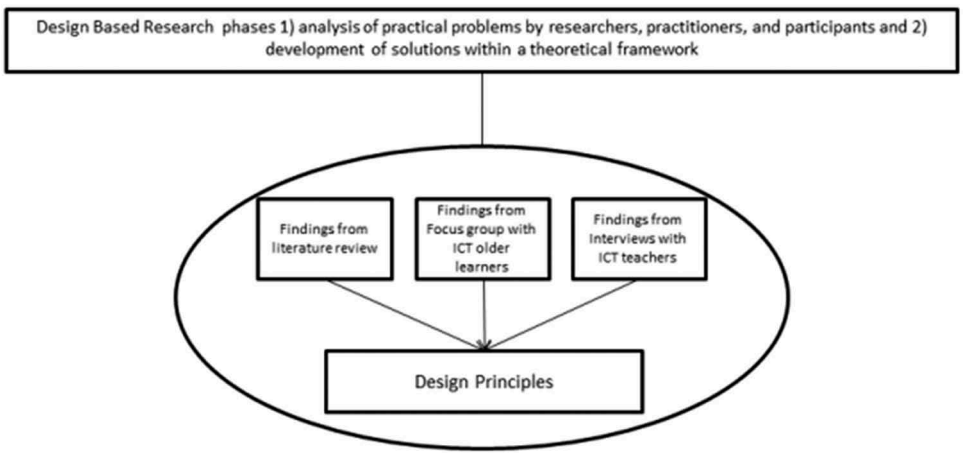

Figure 1. Sources that informed the creation of the proposed design principles.

Two interviews were undertaken with professionals working on teaching older adults how to use ICTs. The interviewees were the academic coordinator and one teacher in the area of ICT, working on the Institutional Program for Adults and Older Adults at the Universidad de Costa Rica (www.piam.ucr.ac.cr).

The sources used to produce the design principles are graphically represented as follows (see Figure 1):

Data analysis

Common themes from the research literature on the relevant theory were extracted, and the references for each theme are reported. As the focus group and the interviews were dealing with similar issues, we analyzed data from both sources by conducting an inductive process of content analysis (Hsieh & Shannon, 2005). Following Mayring (2000), audio data from both sources was listened to, and a set of codes and analytical categories was defined. After 10% of the material had been reviewed, the codes and categories were revised, and this was done again after 50% of the material had been reviewed. At both intervals, codes and categories were subsumed, and new ones were created. The analytical categories and the codes´ system are reflected in the tables in the results section.

After the coding system was created, the audio-taped data from the interviews and the focus group was coded using NVivo 11 software. The results from the coding process were represented by tables reflecting frequencies of codes. Finally, four main categories were identified, and the meanings and relationships between those categories and the themes extracted from the theory were analyzed (McQueen, McLellan, Key, & Milstein, 2009). Based on this analysis, we created a set of context-sensitive design principles that comprise suggestions from theory, learners, and teachers.

Reliability and validity criteria

By drawing and contrasting data from different sources (theory, participants, and practitioners), and gathered using different methods (literature review, focus group and interviews) we tried to reduce the chances of reaching false conclusions (Hammersley, 2008; Mayring, 2000) and to provide complementary information (Hammersley, 2008). To fulfil the principles of contextualization (Klein & Miyers, 1999) and transparency, we offer the reference to our previous work for a detailed description of the context and the study participants, and here we offer the description of each research phase so the reader can follow the process to arrive at the proposed design principles.

Results

First, the common themes identified from the scientific literature are summarized, and references are presented. Second, we provide a description of the learners and the findings from the content analysis of the focus group and interviews with ICT teachers. Finally, a set of design principles derived from the previous sources is presented.

Findings from the scientific literature

Data from the literature reviewed were grouped around common themes. Table 1 describes these themes and sources.

In summary, the findings from the ICT literature comprise the following aspects: including older people´s interests and needs as a central component of the learning intervention, facilitating social interaction and collaborative learning, presenting learning as a progressive continuum, supporting memory and declining cognitive abilities, and considering limited experience of using ICTs.

Table 1. Common themes related to older adults and ICT learning in the scientific literature.

ICT learning is based on personal interests, and it is motivated and sustained through social interaction	Ala-Mutka et al. (2008); Buiza et al. (2009); Commission of the European Communities (2001); Czaja et al. (2006); Czaja and Sharit (2012); Facal et al. (2009); Gamberini et al. (2006);Hakkarainen (2012); Sayago et al. (2013), (Sayago et al., 2011); Van der wardt et al. (2012); Vroman et al. (2015)
ICT learning is a collaborative process	Ala-Mutka et al. (2008); Buiza et al. (2009); Commission of the European Communities (2001); Facal et al. (2009); Vroman et al. (2015)
There must be opportunities to apply the skills learned in daily life	Ala-Mutka et al. (2008); Buiza et al. (2009); Commission of the European Communities (2001); Czaja and Sharit (2012); Sayago et al. (2013), (2011); Van der wardt et al. (2012); Vroman et al. (2015)
Cognitive functions involved in ICT learning must be supported	Ala-Mutka et al. (2008); Facal et al. (2009); Sayago et al. (2013), (2011); Van der wardt et al. (2012); Vroman et al. (2015)

Profile of older adults interested in ICT learning

The older ICT learners who participated in the study were five females and two males living in urban areas in the capital city or in other important urban centers. The teachers reported that, in contrast to other program courses and previous studies (Castro & Salazar, 2014), ICT courses promote the inclusion of more male participants. During the focus group, the discourse seemed to reproduce gender stereotypes, portraying it as more natural for males to interact with technology. However, in recent years, housewives have been attending ICT courses to satisfy personal interests.

Thus, topics related to ICTs seem to promote a more balanced participation in learning processes both by allowing women to explore the technology domain and by facilitating male social participation during old age.

Most of the learners viewed themselves as active people both inside and outside the home. They participated in several groups for social activities, exercising, and learning. Some of them were not active in groups but were active in housework, farming, and helping family and neighbors with different issues. All participants were retired, but they perceived their time as scarce and valuable.

> "Now, my three children are married, I live alone with my husband, I participate in groups, I assist in an aerobics exercise group, I go to lectures and conferences, I am busy all the time. I make things at home, I do not like to be lazy, and I do a lot of handcrafts at home." Code/subcategory: Participating in social/learning groups and time limitations, (Female, housewife)

Consequently, they were only willing to invest time in learning content they found useful and necessary.

Findings from content analysis of focus group and interviews

The findings are presented according to four main clustered categories: knowledge related to ICTs; negative emotions related to learning about and using ICTs; perceptions of learning and learning about and using ICTs; and suggestions for designing learning interventions to facilitate using ICTs for cognitive activity and social interaction.

Table 2 presents the main categories, subcategories (derived from the codes), and their frequencies in the data, as well as the source (learners and teachers) from which the subcategories emerged. Subsequently, each category is described, and some quotes from the data are presented to illustrate the findings.

Table 2. Summary of categories and subcategories from the coding process.

Categories	Subcategories	Sources	Frequency
Knowledge related to ICTs	Structured introduction for how to use ICT is not available	Learners	7
		Teachers	3
	Lack of abilities to understand and manage the information available	Learners	8
		Teachers	1
	Information overload	Learners	4
	Total		**23**
Negative emotions related to learning about and using ICTs	Fear	Learners	16
		Teachers	7
	Shame	Learners	7
		Teachers	1
	Need for including emotions in the learning process	Teachers	**7**
	Total		**38**
Perceptions of learning and learning about and using ICTs	**Perceptions of learning**		
	Capability and willingness to learn new things vs slower learning processes	Learners	17
		Teachers	5
	Stereotypes of older adults	Learners	5
		Teachers	2
	Learning as self-realization	Learners	8
		Teachers	13
	Retirement and spare time as learning opportunities	Learners	5
		Teachers	4
	Age-related disabilities as a limitation for learning	Teachers	1
	Perceptions of learning and using ICT		
	Supporting aspects for learning and using ICT		
	Learning about ICTs is related to personal needs and expectations	Learners	11
		Teachers	35
	ICTs as a learning tool and for practical tasks	Learners	13
		Teachers	7
	ICT learning is reinforced by positive learning outcomes	Learners	1
		Teachers	6
	ICT learning is influenced by positive and negative attitudes toward ICTs	Learners	6
	ICT learning is modeled by peers	Teachers	5
	Obstacles for learning and using ICT		
	During ICT learning, constant external help and support is required	Learners	3
		Teachers	6
	External ownership of the ICT knowledge	Learners	8
	Others	Learners	5
		Teachers	2
	Total		**168**
Suggestions for designing learning interventions to facilitate using ICTs for cognitive activity and social interaction	Creating a respectful learning environment/ promoting social interaction	Learners	6
		Teachers	19
	Being aware of changes in learning needs over time	Teachers	14
	Managing fast changes in ICTs and slow learning processes	Learners	8
		Teachers	4
	Implementing learning about and using ICTs as a progressive process	Teachers	12
	Having balanced timing during learning	Learners	4
		Teachers	8
	Including older adults in designing learning interventions	Teachers	8
	Encouraging independence when using ICTs	Teachers	6
	Using ICTs as a tool for social interaction	Teachers	4
	Evaluating effectiveness related to satisfaction of participants' needs and expectations	Teachers	3
	Promoting a structured learning environment	Teachers	2
	Acknowledging older adults' knowledge	Learners	2
	Ensuring an intergenerational learning environment	Teachers	2
	Others	Teachers	9
	Total		111

Knowledge related to ICTS

Learners knew of the considerable amount of information available concerning ICTs and of resources that can be accessed by using ICTs. However, they either lacked access to such information or lacked the skills to manage it according to their needs and interests.

Older adults did not find it easy to learn how to use ICTs independently. Consequently, the ideal way to learn how to interact with ICTs would be through structured learning processes; however, such processes are not available:

> "But the formal introduction is missing. Nobody explains to you how to use the device. Even when you go to the shop [...] they give you the mobile phone and that is all; they assume you already know how to use it, there is a user manual that is difficult to understand. Then you depend on friends and young people who know how those things work". Code/subcategory: Structured introduction for how to use ICT is not available, (Male, retiree)

Learners knew that there were resources for helping them during the ICT learning process, such as online help when using the computer, but they did not know where to find them and how to use them. Moreover, they did not know how to match their needs with those resources. This lack of knowledge on how to navigate information on ICTs sometimes makes them feel overloaded and places them in a vulnerable position, as others (younger people) have specific knowledge and they must enter into a dependency relationship to gain access to that knowledge.

Negative emotions related to learning about and using ICTS

Difficulties with memory and attention during the learning process were related to two basic emotions: fear and shame. Participants reported that, when using ICTs, they were afraid of damaging the equipment and the consequences of this, such as losing valuable information, so they were nervous and stressed. Moreover, they felt ashamed of asking questions, making mistakes, and being "slow" learners.

The older people found learning to use ICTs shocking because they had little or no prior experience with technology. Learners suggested that fear can be related to a lack of experience and to fear of something new and new learning processes.

> "I was afraid because I could make some mistake. And you know, all the people behind you are waiting for you, and you know, sometimes you can be slower and you do not have the same ability. You do not want to be pushed; you do not want to be rushed. But, when I was brave and tried it, a lady taught me how to use the system and it was fine." Code: Fear of new things and new knowledge (female, retiree).

Learners also manifested concerns about changes to traditional ways of social interaction, such as having less face-to-face interaction every day. They were also concerned about security and privacy; for example, they were worried about having strangers gain access to their social and family life through social networks. They also feared a negative impact of ICTs on health since, by using ICTs, they could become less active.

They felt shame about not being efficient learners and making mistakes. Their main complaint was that their relatives and members of their social networks did not have enough patience to teach them about or help them use ICTs. Nevertheless, they thought that, over time and with lots of practice, they could become more confident using ICTs.

> "I feel good because I can do things (related to ICT) by myself without help, I feel good because I do not have to ask my son, and see him grimacing and saying 'mommy, I explained you about this, but you do not understand,' I think they do not have patience." Code: Ashamed about asking questions, (Female, housewife)

Fear and shame are related to the reactions from the social environment. Learners and teachers reported several anecdotes in which relatives, especially children, reacted in a negative way when older adults made mistakes, did not understand directions, forgot information about ICTs, or asked the same questions several times. Learners agreed that the best way to learn how to use ICTs is in a structured learning process with other older adults, thus avoiding those negative reactions from

family and friends. Teachers remarked on the need for identifying, understanding, and accepting those emotions to offer resources to support older adults' ICTs learning processes.

Perceptions of learning and learning about and using ICT

Learners perceived themselves as willing and capable of learning new content and skills. However, they reported learning in general being slower than when they were younger, as well as being particularly slower than younger people at learning about and using ICTs.

> "I want to interact with technology in the way my grandchild or my daughter do, and I cannot; because I am not able, or I do not know if one is not intelligent enough, or what? But, I think one can do it with some teaching and a bit of practice, and then you can feel good about yourself." Code: Capability and willingness to learn new things vs slower learning processes, (Female, housewife)

Besides their main perceptions of themselves as active, productive, and capable people, learners also evidenced some stereotypes, such as older adults as not being capable of learning new things. However, when these stereotypes appeared, they reflected on them and tried to balance their positive perceptions by affirming that, despite learning being slower and more difficult than it was before, it is still possible.

They recognized that their learning process was different, but they did not appear to understand these changes. The teachers also referenced some changes and stereotypes that older learners have to deal with. Thus, it seems important to include opportunities to analyze changes in cognitive functioning and stereotypes of aging in learning interventions.

Learners perceived that learning processes help them to feel satisfied. Since they did not need to learn in service of work, home, or family duties, learning processes were aimed at personal development. Accordingly, obtaining positive learning outcomes reinforced their self-esteem and supported their positive perceptions:

> "I like the idea that 'nobody is born knowing everything', then it is important to have experiences and to collaborate [...] if somebody teaches you and you practice a bit, then you can make it, and you feel good." Code: Learning as self-realization. (Female, housewife)

In contrast with the literature, learners did not consider physical limitations, such as hearing or vision deficits, as limitations for learning.

In agreement with the literature, learners only reported willingness to commit to learning about and using ICTs if they found this to be useful. This approach to learning to some extent reflects the selection, optimization, and compensation (SOC) model described by Baltes & Baltes (1990) and Freund & Baltes (1999); Freund & Baltes (1998)). Consequently, a main supporting factor for learning is relating ICT to concrete needs in their daily life:

> "In our case, we need to make decisions to what extent I will learn about ICT? How much do I need it and what for?" Code: Learning about ICTs is related to personal needs and expectations, (Male, retiree)

Learners perceived ICTs as tools to support different tasks and mentioned different needs for using ICTs, such as communication, interaction, learning, and practical tasks. In this regard, teachers reported that the educational program is organized with basic courses at the beginning, followed by a set of optional courses, so that participants can choose what fits better with their needs. Learners and teachers stated the importance of promoting positive learning outcomes and positive attitudes toward ICTs to reinforce the learning process. Teachers emphasized the modeling role of peers, as experienced learners can inspire and guide other older adults in learning about and using ICTs.

Obstacles to ICT learning included aspects that made learners feel vulnerable, such as the need for constant external support and their perception that younger people had the knowledge about ICT, so their own knowledge and experience were not valued:

> "I do not like this sensation of vulnerability, you must accept what they say and you do not know if it is good or bad. […]. There is another problem; there are people that do not like to explain to you, they do not like to or they cannot." Code: External ownership of the ICT knowledge, (Male, retiree)

Other obstacles were the need for more ergonomic devices; for example, learners found laptop mousepads to be insufficiently ergonomic. However, learners recognized that touch screen and mobile devices were improving ergonomic design. Finally, learners and teachers reported that, as a result of anxiety, failures in basic processes, such as observation and reading, can occur during the learning process.

Suggestions for designing learning interventions to facilitate using ICT for cognitive activity and social interaction

Based on experiences dealing with negative emotions and stereotypes about aging, learners and teachers suggested the need for a respectful, friendly, and safe environment in which learners can feel comfortable asking for as much help as they need.

> "Teachers must have a lot of patience and answer all the questions that we formulate […] teachers must be kind and have patience." Code: Creating a respectful learning environment/promoting social interaction, (Male, retiree)

In such an environment, it is important to share with peers, in relation to both the learning process and social aspects. Teachers suggested being aware that learners' needs and interests change over time; for example, learners recently started asking for courses about social networking and mobile devices. Because of the rapid development of technology, they emphasized the need to identify priorities so that learners are not overwhelmed by all the possibilities technology can offer.

Teachers reported that the learning process has developed on a continuum from an introduction to different devices and applications to a personal pathway. Learners also suggested having enough time to develop and finish the learning activities.

Teachers reported that older learners were included in designing the program's courses by listening to their comments in informal settings and by paying attention to their evaluations of courses and teachers. However, learners' participation is not a formal aspect in designing the courses or the framework of the institutional program. Nevertheless, teachers recognized that it could be a good practice for designing suitable learning interventions and to motivate older people to participate.

Teachers suggested promoting independence when using ICTs, so that older people can be clear about what they want to do, the type of help they will require, and the availability of sufficient resources to get help. Another suggestion was using ICTs for promoting social interaction; however, as stated in section "Negative emotions related to learning about and using ICT", it will require a balance with face-to-face interaction.

Teachers noted that evaluating suitable learning interventions must address their effectiveness in satisfying individuals' needs:

> "You can hear them exchanging information, for example, 'I found this report or article, I'm going to send it to you' or 'I found this webpage, have a look.' They are also able to enroll in different courses using an online system." Code: Evaluating effectiveness related to satisfaction of participants' needs and expectations, (Coordinator of educational program)

Teachers proposed having a structured learning environment with a teacher and scheduled and well-defined activities. However, this does not mean a formal environment, as, at the same time, learners also want flexibility to combine their different activities, dealing with the developmental tasks during aging and sharing their own knowledge:

> "We also have something to teach to them [referring to young people], they know how to use the computer, but ask them something about reasoning, ask them the multiplication tables, and you see that they do not know it." Code: Acknowledgment of older adults' knowledge, (Female, retiree)

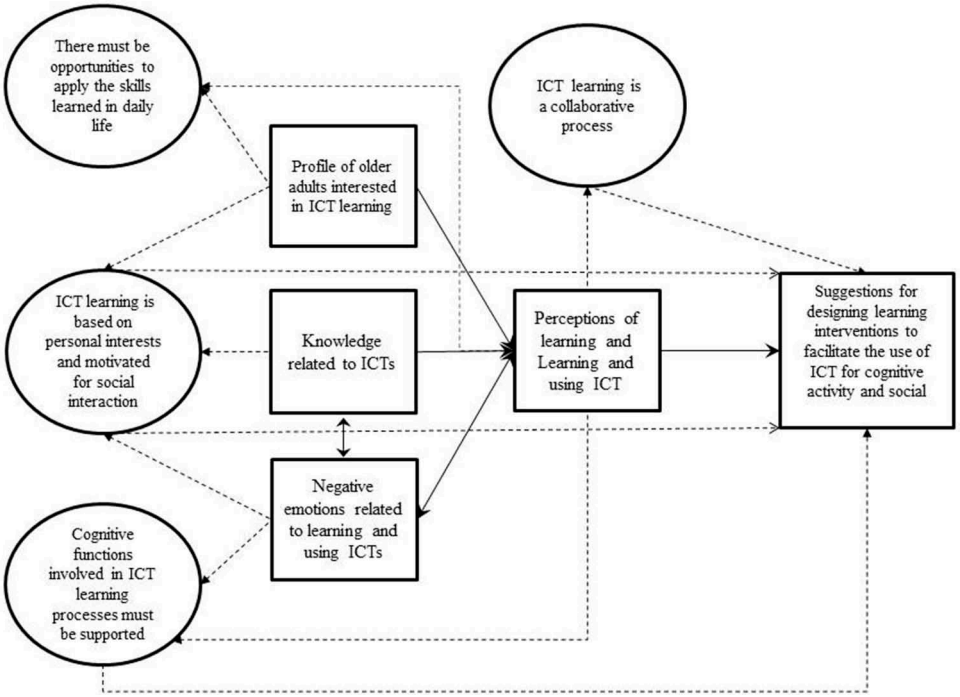

Figure 2. Summary of data analysis and results. Circles represent themes in theory, and squares represent analysis categories. Dashed lines and arrows depict complementarity between analysis categories and themes in theory. Continuous lines and arrows illustrate relationships between analysis categories, and double arrows depict mutual influence.

Teachers also suggested ensuring an intergenerational learning environment. Thus, younger participants (60–70 years old) can support older learners on the basis of experiencing common age-related changes. Other suggestions included working with small groups and several teachers to support different learning rhythms, including individual meetings for those who need additional support, and having written material and many opportunities to practice the learned skills to support learners' memory and attention.

Relationships between theory, learner profile, and the clustered analysis categories

Figure 2 presents the identified relationships between theory and analysis categories as well as how they informed the design principles.

Detailed descriptions and examples from learners' and teachers' data complemented the themes extracted from theory. For example, the category "Perceptions of learning and learning about and using ICT" brought detailed information and examples to illuminate the following theoretical themes: a) "ICT learning is a collaborative process," where teachers remarked on the modeling role of peers during the learning process; b) "There must be opportunities to apply the learned skills in daily life," where learners and teacher elaborated on ICTs both as learning tools and as means for accomplishing practical tasks; and c) "Cognitive functions involved in ICT learning must be supported," where learners and teachers reflected about the capability and willingness of older adults to learn as well as their perceived slower learning processes.

A reciprocal relationship can be depicted between "knowledge related to ICTs" and "negative emotions related to learning about and using ICTs," as lack of ICT knowledge influences feelings of fear and shame, while negative emotions can influence information overload and

cause difficulties in understanding and managing available information. Other reciprocal relationships arise between "perceptions of learning and learning about and using ICTs" and "negative emotions related to learning about and using ICTs," as experiences of vulnerability represented obstacles for learning about and using ICT, while positive learning outcomes can support learning processes and decrease negative emotions.

Common themes from theory, analysis categories, and their relationships were reflected in the suggestions for designing learning interventions to facilitate using ICTs for cognitive activity and social interaction that informed the following design principles.

Design principles for learning interventions for using ICTS for cognitive activity and social interaction

(1) Organize the learning activities around interesting topics for older adults.
(2) Encourage individual participation and support a collaborative learning environment.
(3) Support social interaction and social networking.
(4) Facilitate spaces to explore and reflect on emotions and stereotypes related to learning about and using ICTs as older learners.
(5) Offer a sustained support system.
(6) Provide resources to support declining cognitive abilities.
(7) Develop a broad perspective concerning ICTs and how to match them to personal interests and needs.
(8) Provide a safe learning environment in which participants' experiences and knowledge are respected.

These principles can guide the design and implementation of learning facilities to accommodate learners' needs and preferences. For example, principle 1 could be realized by using ICTs to implement reminiscence protocols, activating autobiographical memory (ABM), and allowing older people to share personal stories about their lives and to share their knowledge; this creates a friendly environment and rapport among participants, helps learners to develop their identity during the aging process, and improves other cognitive abilities (Kenyon, Bohlmeijer, & Randall, 2010; Salazar-Villanea, 2010; Westerhof, Bohlmeijer, & Webster, 2010)

Discussion

The study aimed to provide context-sensitive design principles that could guide the design of suitable learning interventions to enable older people to use ICTs for cognitive activity and social interaction. Using a DBR approach, we analyzed data from scientific literature, learners, and teachers and proposed eight design principles that are context and culture specific but could be useful in similar contexts.

The proposed design principles argue for the relevance of a respectful learning environment, the need for in-depth comprehension of age-related changes, and support for adaptation to such changes. They also encourage providing time and space to reflect on emotions and stereotypes related to the learning process and interacting with ICTs and acknowledging participants' individuality.

Learners and teachers could see the potential of ICTs in supporting successful and active aging (Ala-Mutka et al., 2008; Dalli, Kroes, & Geoghegan-Quinn, 2011; Sayago et al., 2013; Vroman et al., 2015), by promoting cognitive activity and social interaction. However, this requires a particular approach to overcoming the digital divide, as learners reported lacking the abilities to access and manage information concerning devices and ICTs applications, hindering their ability to identify how ICTs can support their needs and interests.

Learners and teachers pointed out that negative emotions play a fundamental role in older adults' ICT learning processes. These emotions mediated their motivation to start and continue learning about and using ICTs as well as their performance during the learning process. Consequently,

besides supporting cognitive abilities required to learn about and use ICTs (Ala-Mutka et al., 2008; Facal et al., 2009; Sayago et al., 2013; Sayago, Sloan, & Blat, 2011; Van der wardt, Bandelow, & Hogervorst, 2012; Vroman et al., 2015), it is also important to address these negative emotions.

The role of relatives and friends in older adults' ICT learning presents an opportunity for further analysis of social representations of older adults interacting with ICTs as well as how to elicit proper support from family and friends. These aspects highlight the role of communities and societies in creating adequate conditions to promote successful and active aging (Featherman, Smith, & Peterson, 1990; WHO, 2002). Older adults reported willingness to learn and adopt ICTs in their daily lives; the question is how societies are adjusting and can adjust in future in order to support them.

Even though learners recognized the potential of ICTs in terms of socializing, they require traditional forms of social interaction and prefer a balance between face-to-face and ICT-mediated interaction This points to the potential of having a strong focus on communication and social networking applications, not only promoting social interactions but also sharing personal experiences and emotions during the learning process.

Taking into account that learners' interests, needs, and expectations are crucial in motivating and sustaining efforts in learning about and using ICTs, an initial evaluation of a learning intervention's effectiveness must be related to the extent to which it accommodates individual needs. In a second phase, evaluation must be focused on the effects on cognitive performance and social interaction. This can be achieved by implementing a formative evaluation, as suggested in DBR approaches (Coto, 2010; Wang & Hannafin, 2005).

The proposed design principles assume older learners as capable of learning and interacting with ICTs, as long as the learning content is related to their needs and expectations and the learning environment and supporting resources are appropriate. Design principles also pointed to learning as a mean of personal development and self-realization. Thus, beyond the instrumental benefits derived from the learning process, it is also related to the learner's identity and his/her feeling like a valuable member of society.

In an effort to document different perspectives to support context-sensitive design principles for designing tailored learning interventions, we combined data from different sources and methods, moving from a general approach from theory to a more detailed exploration of the personal perceptions of learners and teachers. This approach allowed us to present design principles that were initially generated in a local setting but that have the potential to be implemented in other settings in other cultural and/or geographical regions (Coto, 2010; Wang & Hannafin, 2005).

Conclusions

Learners and teachers noted that older adults are interested in learning how to use ICTs with a view to enhancing cognitive activity and social interaction. Their openness and willingness is guided by their perception of the usefulness of the learning outcomes and the inclusion of ICTs in their daily lives.

The proposed design principles reflect that this kind of learning intervention, besides focusing on traditional aspects, such as length, content, activities, and materials, must also include and reflect on wider aspects that have an influence on the learning process, such as age-related changes and strategies to cope with them, the interaction needs and preferences of older adults, the emotions and stereotypes related to learning about and using ICTs, and social support for ICT learning.

Finally, the study indicates that considerable effort is still needed to realize the potential of ICTs in supporting a successful and active aging process, and including older adults and teachers in such efforts could be a strategy for designing learning interventions that accommodate the common and individual needs of older adults.

Limitations

The study only included older adults who were interested in learning and using ICTs, which limits the generalization of the research findings to similar learners. Because of limited resources, the study does not include an inter-rater reliability measure.

Acknowledgments

We wish to thank Omar Dengo Foundation, Costa Rica, and Ana Cecilia Murillo, Ana Lourdes Acuña Zúñiga, Elena Carreras, Emmanuel Fonsega Ugalde, Natalia Rodríguez, and Carolina Rodriguez for their support during recruitment and data collection processes.

Funding

This project has been funded with support from the European Commission thanks to the Erasmus Mundus Action 2 scholarship project AMIDILA. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

Notes on contributors

María Dolores Castro Rojas is psychologist and has a master's degree in psychological research. Currently, she is a PhD candidate in the Human Centered Communications and Informatics program of the Psychology and Communication Department at Aalborg University, Denmark. Her research interest include: ICT and media in teaching and learning, ICT and media and successful and active aging, Human development, Aging, and Cognitive sciences. For further information, please visit: http://personprofil.aau.dk/133966

Ann Bygholm is professor in Communications and Informatics in the Psychology and Communication Department at Aalborg University, Denmark. Her research area is Communications and Informatics. For further information, please visit: http://personprofil.aau.dk/101779?lang=en

Tia G.B. Hansen is associate professor in developmental psychology in the Psychology and Communication Department at Aalborg University, Denmark. Her research areas are general psychology and applied psychology. For further information, please visit: http://personprofil.aau.dk/101929?lang=en#

References

Ala-Mutka, K., Malanowski, N., Punie, Y., & Cabrera, M. (2008). *Active Ageing and the Potential of ICT for Learning*, Spain: European Commission, Institute for Prospective Technological Studies. doi:10.2791/33182

Anguera, J. A., Boccanfuso, J., Rintoul, J. L., Al-Hashimi, O., Faraji, F., Janowich, J., . . .Gazzaley, A. (2013). Video game training enhances cognitive control in older adults. *Nature*, *501*(7465), 97–101. doi:10.1038/nature12486

Baltes, P., & Baltes, M. (1990). Psychological perspectives on succesful aging: The model of selective optimization with compensation. In P. Baltes, & M. Baltes (Eds.) *Successful aging perspectives from the behavioral sciences* (First pp.1–34) New York, NY: Cambridge University Press. 10.1017/CBO9780511665684

Bosma, H., Van Boxtel, M. P. J., Ponds, R. W. H. M., Jelicic, M., Houx, P., Metsemakers, J., . . . Metsemakers, J. (2002). Engaged lifestyle and cognitive function in middle and old-aged, non-demented persons: A reciprocal association?. *Z Gerontol Geriat*, *35*, 575–581. doi:10.1007/s00391-002-0080-y

Buckner, R. L. (2004). Memory and executive function in aging and ad: Multiple factors that cause decline and reserve factors that compensate. *Neuron*, *44*(1), 195–208. doi:10.1016/j.neuron.2004.09.006

Buiza, C., Gonzalez, M. F., Facal, D., Martinez, V., Diaz, U., Etxaniz, A., . . . Yanguas, J. (2009). Efficacy of cognitive training experiences in the elderly: Can technology help? In *Universal Access in Human-Computer Interaction. Addressing Diversity UAHCI 2009*. (pp. 1–10). Retrieved from https://link.springer.com/chapter/10.1007/978-3-642-02707-9_37

Castro, M. D. (2012). *Rendimiento cognitivo en funciones ejecutivas y memoria y nivel de participación en personas mayores de 60 años que pertenecen a grupos organizados de personas mayores en la provincia de San José* (Unpublished master´s thesis). San José, Costa Rica: Universidad de Costa Rica.

Castro Rojas, M. D., Bygholm, A., & Hansen, T. G. (2016). Using information and communication technologies to promote healthy aging in Costa Rica: Challenges and Opportunities. In Zhou J., Salvendy G. (Eds) *Human Aspects*

of IT for the Aged Population. Healthy and Active Aging. ITAP 2016.Lecture Notes in Computer Science, *9755*, 194–206. Springer, Cham. doi:10.1007/978-3-319-39949-2_19

Castro, M. D., & Salazar, M. (2014). Rendimiento cognitivo de personas mayores que participan en grupos organizados en la provincia de San José/Cognitive performance of elder people participating in elder´s organized groups in San José. *Actualidades En Psicología*, *28*(116), 41–53. doi:10.15517/ap.v28i116.14891

Charness, N., & Boot, W. R. W. (2009). Aging and information technology use: Potential and barriers. *Current Directions in Psychological Science*, *18*(5), 253–258. doi:10.1111/j.1467-8721.2009.01647.x

Commission of the European Communities. (2001). *Making a european area of lifelong learning a reality*. Brussels. Retrieved from http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2001:0678:FIN:EN:PDF

Coto, M. (2010). *Designing for change in university teaching practices: A community of practice approach to facilitate university teacher professional development in ict and project-oriented problem pedagogy*. Aalborg, Denmark: Department of Communication and Psychology, Aalborg University.

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., & Sharit, J. (2006). Factors predicting the use of technology: Findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychology and Aging*, *21*(2), 333–352. doi:10.1037/0882-7974.21.2.333

Czaja, S. J., & Sharit, J. (2012). *Designing training and instructional programs for older adults*.Florida, USA: CRC Press Taylor & Francis Group. Retrieved from http://books.google.com/books?hl=en&id=Fe655VQDfRcC&pgis=1

Dalli, J., Kroes, N., & Geoghegan-Quinn, M. (2011). Strategic implementation plan for the european inovation partnership on active and healthy ageing - steering group working document. *European Innovation Partnership on Active and Healthy Ageing*, (November), 1–16. Retrieved from http://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/steering-group/implementation_plan.pdf#view=fit&pagemode=none

European Commission. (2017). *Eurostat-data explorer*. Retrieved from Eurostat website http://ec.europa.eu/eurostat/data/database

Facal, D., Buiza, C., González, M. F., Talantziz, F., Urdaneta, E., Martínez, V., … Soldatos, J. (2009). *Cognitive games for healthy elderly people in a multitouch screen*. III International Congress on Domotics, Robotics and Remote Assistance for All DRT4all 2009 (pp. 91–97). Barcelona, Spain: ONCE Foundation for Disabled People Cooperation and Social Integration.

Featherman, D. L., Smith, J., & Peterson, J. G. (1990). Successful aging in a post-retired society. In P. Baltes, & M. Baltes (Eds.), *Successful aging perspectives from the behavioral sciences* (First pp.50–93) New York, NY: Cambridge University Press. 10.1017/CBO9780511665684.005

Fernández Ballesteros, R.,Caprara, M. G., & García, L. F. (2005). Vivir con vitalidad-m®: A european multimedia programme. *Psychology in Spain*. *9*,1–12.

Fernández-Ballesteros, R. (2008). *Active aging: The contribution of psychology*. R. Fernández-Ballesteros (Ed.), Fisrt Ashland, OH, US: Hogrefe & Huber Publishers.

Fernández-Ballesteros, R., Molina, M. Á., Schettini, R., & Del Rey, Á. L. (2012). Promoting active aging through university programs for older adults. *GeroPsych*, *25*(3), 145–154. doi:10.1024/1662-9647/a000064

Freund, A., & Baltes, P. (1999). Selection, optimization, and compensation as strategies of life management: Correction to freund and baltes (1998). *Psychology and Aging*, *14*(4), 700–702. doi:10.1037/0882-7974.13.4.531

Freund, M., & Baltes, P. (1998). Selection, optimization, and compensation as strategies of life management: Correlations with subjective indicators of successful aging. *Psychology and Aging*, *13*(4), 531–543. doi:10.1037/0882-7974.13.4.531

Gamberini, L., Alcaniz, M., Barresi, G., Fabregat, M., Ibanez, F., & Prontu, L. (2006). Cognition, technology and games for the elderly: An introduction to ELDERGAMES Project. *PsychNology Journal*, *4*(3), 285–308. Retrieved from http://psychnology.org/File/PNJ4(3)/PSYCHNOLOGY_JOURNAL_4_3_GAMBERINI.pdf

Hakkarainen, P. (2012). "No good for shovelling snow and carrying firewood": Social representations of computers and the internet by elderly Finnish non-users. *New Media & Society*, *14*(7), 1198–1215. doi:10.1177/1461444812442663

Hammersley, M. (2008). Troubles with triangulation. In M. Bergman Ed., *Advances in mixed methods research* First (pp.22–36). London: Sage. 10.4135/9780857024329

Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2009). Enrichment effects on adult cognitive development can the functional capacity of older adults be preserved and enhanced?. *Psychological Science in the Public Interest*, *9*(1), 1–65. doi:10.1111/j.1539-6053.2009.01034.x

Hsieh, H.-F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15*(9), 1277–1288. doi:10.1177/1049732305276687

Hultsch, D. F., Hertzog, C., Small, B. J., & Dixon, R. A. (1999). Use it or lose it: Engaged lifestyle as a buffer of cognitive decline in aging?. *Psychology and Aging*, *14*(2), 245–263. doi:10.1037/0882-7974.14.2.245

Instituto Nacional de Estadística y Censos [INEC]. (2012). Censos 2011 | INSTITUTO NACIONAL DE ESTADISTICA Y CENSOS. Retrieved from http://www.inec.go.cr/censos/censos-2011

Kenyon, G., Bohlmeijer, E., & Randall, W. (Eds.). (2010). Storiying later life: Issues, investigations, and interventions in narrative gerontology. Oxford, England: Oxford University Press.

Klein, H. K., & Miyers, M. D. (1999). A set of principles for conducting and evaluating interpretetive field studies in information systems. *MIS Quarterly*, *23*(1), 67–94. doi:10.2307/249410

Lowe, C., & Rabbitt, P. (2005). Cognitive models of ageing and frontal lobe deficits. In P. Rabbitt (Ed.), *Methodology of frontal and executive function* (pp. 38–58). Hove, UK: Psychology Press.

Mayring, P. (2000). Qualitative content analysis. Retrieved April 4, 2017, from http://www.qualitative-research.net/index.php/fqs/article/view/1089/2385

McQueen, M., McLellan, E., Key, K., & Milstein, B. (2009). Codebook development for team-based qualitative analysis. In Krippendorff, K (Ed.). *The content analysis reader* (pp. 211–219). Los Angeles, US: SAGE.

Plehn, K., Marcopulos, B. A., & Mclain, C. A. (2004). The relationship between neuropsychological test performance, social functioning, and instrumental activities of daily living in a sample of rural older adults. *The Clinical Neuropsychologist*, *18*(1), 101–113. doi:10.1080/13854040490507190$16.00

Rebok, G. W., Ball, K., Guey, L. T., Jones, R. N., Kim, H. Y., King, J. W., … Willis, S. L. (2014). Ten-year effects of the advanced cognitive training for independent and vital elderly cognitive training trial on cognition and everyday functioning in older adults. *Journal of the American Geriatrics Society*, *62*(1), 16–24. doi:10.1111/jgs.12607

Reeves, T. (2006). Design research from a technology perspective. In J. Van Den Akker, K. Gravemeijer, S. Mckenney, & N. Nieveen (Eds.)., *Educational design research* (pp. 86–109). London: Routledge. Retrieved from http://www.fisme.science.uu.nl/publicaties/literatuur/EducationalDesignResearch.pdf#page=102

Rowe, J. W., & Kahn, R. L. (1997). Successful aging. *The Gerontologist*, *37*(4), 433–440. doi:10.1093/geront/37.4.433

Salazar-Villanea, M. (2010). *Recordando experiencias. Programa de intervención con reminiscencia para personas adultas mayores. Guís para terapeutas y CD con estímulos visuales* (1st ed.). San José, Costa Rica: Instituto de Investigaciones Psicológicas, Universidad de Costa Rica.

Sayago, S., Forbes, P., & Blat, J. (2013). Older people becoming successful ict learners over time: Challenges and strategies through an ethnographical lens. *Educational Gerontology*, *39*(7), 527–544. doi:10.1080/03601277.2012.703583

Sayago, S., Sloan, D., & Blat, J. (2011). Everyday use of computer-mediated communication tools and its evolution over time: An ethnographical study with older people. *Interacting with Computers*, *23*(5), 543–554. doi:10.1016/j.intcom.2011.06.001

Schaie, K. (2005a). *Developmental influences on adult intelligence: The Seattle longitudinal study*. Oxford, England: Oxford University Press.

Schaie, K. (2005b). What can we learn from longitudinal studies of adult development?. *Research in Human Development*, *2*(3), 133–158. doi:10.1207/s15427617rhd0203_4

Schooler, C., & Mulatu, M. S. (2001). The reciprocal effects of leisure time activities and intellectual functioning in older people: A longitudinal analysis. *Psychology and Aging*, *16*(3), 466–482. 10.I037//0882-7974.16.3.466. doi:10.1037/0882-7974.16.3.466

Seeman, T. E., Lusignolo, T. M., Albert, M., & Berkman, L. (2001). Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur studies of successful aging. *Health Psychology*, *20*(4), 243–255. doi:10.1037/0278-6133.20.4.243

Smith, & Kosslyn, S. (2014). *Cognitive psychology : Mind and brain* (5th ed.). Harlow, England: Pearson.

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia*, *47*(10), 2015–2028. doi:10.1016/j.neuropsychologia.2009.03.004

Thompson, G., & Foth, D. (2005). Cognitive-training programs for older adults: What are they and can they enhance mental fitness?. *Educational Gerontology*, *31*(8), 603–626. doi:10.1080/03601270591003364

Van der wardt, V., Bandelow, S., & Hogervorst, E. (2012). The relationship between cognitive abilities, well-being and use of new technologies in older people. *Gerontechnology : International Journal on the Fundamental Aspects of Technology to Serve the Ageing Society*, *10*(4), 187–207. doi:10.4017/gt.2012.10.4.001.00

Vroman, K. G., Arthanat, S., & Lysack, C. (2015). "Who over 65 is online?" Older adults' dispositions toward information communication technology. *Computers in Human Behavior*, *43*, 156–166. doi:10.1016/j.chb.2014.10.018

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, *53*(4), 5–23. doi:10.1007/BF02504682

Wang, X. W., & Pei, J. J. (2012). Leisure activities, cognition and dementia. *Biochimica Et Biophysica Acta - Molecular Basis of Disease*, *1822*(3), 482–491. doi:10.1016/j.bbadis.2011.09.002

Westerhof, G. G., Bohlmeijer, E., & Webster, J. D. J. (2010). Reminiscence and mental health: A review of recent progress in theory, research and interventions. *Ageing & Society*, *30*(4), 697–721. doi:10.1017/S0144686X09990328

Willis, S. L., Tennstedt, S. L., Marsiske, M., Ball, K., Elias, J., Koepke, K. M., … Wright, E. (2006). Long-term effects of cognitive training on everyday functional outcomes in older adults. *JAMA: The Journal of the American Medical Association*, *296*(23), 2805–2814. doi:10.1001/jama.296.23.2805

Wilson, R. S., Boyle, P. A., Yu, L., Barnes, L. L., Schneider, J. A., & Bennett, D. A. (2013). Life-span cognitive activity, neuropathologic burden, and cognitive aging. *Neurology*, *81*(4), 314–321. doi:10.1212/WNL.0b013e31829c5e8a

World Health Organization [WHO]. (2002). *Active ageing*. World Health Organization [WHO]. Retrieved from http://ec.europa.eu/social/main.jsp?catId=1062&langId=en

World Health Organization [WHO]. (2015). *World health stadistics*. Geneva, Switzerland. Retrieved from http://apps.who.int/iris/bitstream/10665/170250/1/9789240694439_eng.pdf?ua=1&ua=1