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Cognitive-Based E-Learning Design for Older Adults

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Abstract: Aging is highly correlated with a decline in cognitive abilities. Information and communication technologies are nowadays increasingly used for knowledge acquisition, education, cognitive development, etc. Older adults should be prepared to adopt these technologies and take advantage of their capabilities. The purpose of this study was to analyze the cognitive profile of older adults in order to identify the ways that they learn, as well as to analyze older adults' attitudes, to aid in the development of an e-learning platform adapted to their needs. The sample of the study consisted of 103 older adults, aged 55+, from Greece. According to their responses, older adults seemed to prefer e-learning modules that presented the educational content step-by-step and contained practice questions and examples. In addition, respondents had positive attitudes toward the existence of assessment tests for after the completion of each module. Finally, the utilization of explanatory videos and special graphics in the modules was imperative, according to older adults' preferences.

Keywords: older adults; seniors; e-learning; cognitive decline

1. Introduction

The improvement of the quality of life of older adults in an aging society is one of the main priorities of researchers in recent years. Aging is highly correlated with psychological changes and especially with a decline in various cognitive procedures (Baudouin et al. 2009). There is evidence that after the fourth decade of a person's life, cognitive skills stop improving and gradually decline (Clark et al. 2006). Most older adults have impaired cognitive control, which is related to the slump of the prefrontal brain regions (Mather and Carstensen 2005). In addition, short-term memory performance in healthy individuals is positively correlated with gray matter volume (Taki et al. 2011).

It has been reported that more than 50% of individuals aged 60 and over are in danger of cognitive decline. At the same time, the limited amount of education for older adults is considered a risk factor for dementia (Ball et al. 2002). Thus, education during late adulthood could provide protection against dementia (Ardila et al. 2000). Deficits on executive function as well as attention deficits could increase the risk of future falls for older adults (Mirelman et al. 2012). Furthermore, adults show high levels of anxiety as they get older, as they are afraid of the possible consequences of aging (Hertzog et al. 2008). Stress-related factors, as well as environmental factors could affect cognitive health during aging (Scott et al. 2015).

Information and communication technologies (ICTs) have significantly contributed to the improvement of people's everyday activities. As in other sectors, such as education, ICTs are integrated in order to support, enhance and optimize the delivery of knowledge. In recent years, there has been a variety of computerized training programs, which target the cognitive abilities of older adults. These

intervention programs are considered more cost effective and can be used anytime and in any place, without specific instruction (Kueider et al. 2012). In addition, the adoption of ICTs in education has opened new horizons for older adults as e-learning can positively affect their social and political life and generally enhance their self-development. The purpose of this study was to identify specific characteristics for the design of a cognitive-based e-learning platform for older adults. For this reason, this study aimed to analyze the familiarization of older adults with ICTs, their cognitive characteristics, as well as their attitudes towards the learning approach used.

2. Literature Review

2.1. Cognition during Aging

Neuroimaging studies, including diffusion tensor imaging (DTI) or voxel-based morphometry (VBM), provide evidence of structural age-related brain changes (Freiherr et al. 2013). Age-related changes in human brain function are considered factors of lower activation in specific brain regions of older adults (Kramer et al. 2004). Normal aging is related to changes in the frontal lobes (frontal lobe hypothesis), which negatively affect executive function in late adulthood (Dahlin et al. 2008). Executive function, which is responsible for inhibition, shifting and updating, has been related to fall risk in older adults (Springer et al. 2006). In addition, functional magnetic resonance imaging (fMRI) studies provide evidence of age-related changes in white matter, the brain regions which affect executive functioning (Bugos et al. 2007). There is evidence that executive function could affect the self-care capacity of older adults (Insel et al. 2006). Recent studies have shown that every day physical activities, such as basic walking tasks, are associated with poor executive function among older adults (Ble et al. 2005; Coppin et al. 2006; Erickson and Kramer 2009). The results of a study with 909 well-functioning older adults in the US revealed that poor performance in executive function, as well as in verbal memory, could predict gait speed decline (Watson et al. 2010). The study of Ball et al. (2007) revealed that the speed of process training via computer-based nonverbal exercises could improve executive function in older adults. In addition, the study of McAuley et al. (2011) revealed that training of self-efficacy in older adults could improve executive function levels and, especially, task-coordination and inhibition. A study of 128 participants (mean age 69.3 years) revealed that intervention based on helping elementary school students with academic and behavioral issues could improve the executive function and memory of the elderly (Carlson et al. 2008).

Recent studies support the hypothesis that older adults show significantly lower performance on attention-dependent tasks in comparison with younger adults (Gola et al. 2012, 2013). According to Clapp et al. (2011), it is more likely for older adults to get distracted compared to younger adults, especially when multitasking. This susceptibility to distraction could lead to decreased performance in older adults. There is also evidence that visual attention impairment in older adults is associated with mobility problems (Owsley and McGwin 2004). In addition, the promotion of selective attention for the elderly could contribute to fall prevention (Chen et al. 2012). A study of 242 older adults (mean age 75.6 years) showed that brain plasticity-based computerized training containing auditory information processing could improve the attentional skills of the participants (Smith et al. 2009).

Compared to younger individuals, older adults often presented a decline in higher-order cognitive abilities, especially in working memory (Berry et al. 2010; Buschkuehl et al. 2008). Working memory (WM) is the ability to temporarily store and manipulate data for a short period of time (Zinke et al. 2014). In addition, a lack of encoding strategies in late adulthood as well as a lack of environmental support could cause a decline in episodic memory (Bherer et al. 2013). Training studies revealed that the working memory performance of older adults could be improved with appropriate interventions, indicating the existence of brain plasticity in aging (Borella et al. 2010). Furthermore, there is evidence that working memory training can also improve cognitive skills given that there is correlation between working memory capacity and fluid intelligence, as well as with executive functioning (Richmond et al. 2011).

2.2. E-Learning for Older Adults

The process of learning is understood as an internal one, controlled by the learners themselves. This process includes intellectual, emotional, and physiological functions. Learners are not seen as empty containers ready to be filled with facts. Learning is seen as a dynamic process, based on the learning objectives that can be accomplished and the learning experiences, which are defined as interactions between learners and their environments. E-learning, which is considered a relatively new and untraditional instruction method (Nasr 2010), has facilitated educational processes for people around the globe (El-Soud et al. 2010). Originally, the term 'e-learning' (*electronic learning*) derived from advertising industries and described learning arrangements and scenarios where information or communication technology was used to support the learning process or to provide learning materials and contents. According to Berners-Lee et al. (2001), the power of the Internet, and thus Internet-based activities such as e-learning, lies with its universality. In today's transition to an information society, new methods of learning emerge and the provision for equal access for all individuals is imperative (Bakaev et al. 2008). Nevertheless, and despite the fact that information and communication technologies can have an important influence on the life of the elderly (Vandebosch et al. 2005), it appears that older adults lag as far as digital skills, Internet access, and engagement in online activities (e-learning, etc.) are concerned (Quan-Haase et al. 2016).

Bearing in mind that the proportion of elderly adults is increasing in countries throughout the world, many challenges are emerging in regards to the elderly and the ability to provide them with equal opportunities. One of these challenges, aimed at social inclusion, concerns the connection of older adults with the rest of today's society through information technology (Lenić et al. 2013). Barriers blocking older adults to participate in online learning activities appear to be the same as those that prevent them from using computers in general (Notess and Lorenzen-Huber 2007). Individuals that make small or no use of technology are at risk of social exclusion and loss of participation in and interaction with society (Pecino et al. 2012). Advanced age is often associated with the phenomenon of the "digital divide" (Rice and Katz 2003; Vicente and López 2006), which induces inequalities concerning access, use and intensity of use of ICTs (Jackson et al. 2008; Torres Diaz and Moro 2011).

New technologies can improve older adults' autonomy and quality of life by providing opportunities for them to develop and maintain social relationships, to have access to services and care, to improve their lifelong learning habits, and to entertain themselves (Tsang 2012). The elderly are able to acquire new knowledge and to develop new skills, including ICT skills that will help them participate in current innovative processes (Repetto and Trentin 2008). In fact, contrary to popular belief, older adults are positive about their capablility of using computers (González et al. 2015) and tend to adopt new technology when they feel it is beneficial to their way of life (Kok et al. 2012; Rogers 2003). As Wellman and Haythornthwaite (2008) have argued, the Internet, and thus Internet-based activities such as e-learning, is not a standalone, separate sphere but rather part of the everyday routines and regular behaviors of its users. As a result, adoption is not binary (Quan-Haase et al. 2016; DiMaggio and Hargittai 2001) but rather it depends on the characteristics, behaviors, habits, and interests of the learners, which although commonly referred to as "the elderly" or "older adults" cannot be considered a homogenous group (Vandebosch et al. 2005).

Online learning can play an important role in helping older adults become integrated with the rest of society and, as they do, their use of e-learning will gradually increase (Githens 2007). The key conditions for older adults to engage with ICTs, and thus consent to e-learning, may be identified as having some practical computer skills that benefit their lifestyles and overcoming the belief that computers are too complex and not for the elderly (Bakaev et al. 2008). This can be done by acquiring basic ICT knowledge and gaining self-confidence. Understanding and addressing the challenges faced by older adults acquiring computer and Internet-related skills is a necessary prerequisite for designing an effective instructional intervention (Wood et al. 2010).

Older adults usually have great time availability that, along with the absence of spatial and temporal constraints, characterize online learning activities and allow high flexibility in their

participation (Repetto and Trentin 2008). There are obvious advantages of e-learning for the elderly such as overcoming physical remoteness, providing up to date and constantly available learning, making educational activities less expensive, and providing a more individualized (personalized) educational approach to students (Bakaev et al. 2008). The latter is particularly important, given that older adults usually need more time and repetition to acquire knowledge, tend to make more mistakes, and generally need greater support through educational activities (Granger et al. 2002; Jones and Bayen 1998; Githens 2007). Repetto and Trentin (2008) highlight the fact that older adults have different response times, educational needs and motivation in online courses, compared to other users. These differences should be taken into account when designing the course material and choosing the learning strategies and tutoring style for an e-learning course addressing older adults.

If such parameters are taken into account, along with the acquisition of basic ICT skills, older adults will undoubtedly become participants of e-learning programs. Although some view older adult learning as entertainment or a leisure activity, Fisher and Wolf (2000) highlight the need to move beyond such purposes and create an educational model that contributes to greater societal good through self-empowerment, self-control, and self-determination. In this way, distance learning programs for older adults can help foster personal growth, civic engagement, and social action and inclusion (Githens 2007).

3. Method

3.1. Procedure

The purpose of this study was to investigate the learning profile of older adults in order to design a cognitive-based e-learning platform adapted to their needs. For this reason, this study aims to analyze the way that older adults learn, their familiarization with ICTs, and their attitudes toward the different learning modules presented to them. During the first phase, the literature review revealed the state-of-the-art use of ICTs and the cognitive profile of older adults. Based on these findings, we designed the questionnaire "Older Adults and Information and Communication Technologies". The questionnaire was sent to the students enrolled in the Master of Education, Specialization in ICT and Special Education, of the National Center for Scientific Research, Demokritos. Students were asked to forward the questionnaire to their family members over 55 years or to guide them as to how to answer it, in case they had no previous online experience. All valid data collected during the online survey were used for analysis, with the use of the IBM SPSS Statistics Subscription software (Armonk, New York, NY, USA), version 1.0.0.800.

3.2. Participants

The sample of this study consisted of 103 older adults from Greece who answered the online questionnaire on their own or with support of a family member or project team member. A total of 78.6% of the participants surveyed were between 55 and 64 years old, 18.4% were aged between 65 and 74 years old, and only a mere 2.9% were 75 years old or older (Table 1). In addition, two thirds (65%) of the participants were female and the majority live in a civil center (76.7%). In terms of their health conditions, participants had a little difficulty with their vision (mean = 2.068, SD = 0.855) and little or no difficulty with their hearing (mean = 1.379, SD = 0.756) or touch (mean = 1.146, SD = 0.550). Regarding the educational status of the participants, 71.8% had graduated from higher educational institutes while 15.5% did not continue their studies after primary school. The majority of participants had moderate knowledge of the English language, in terms of reading (mean = 3.262, SD = 1.462), writing (mean = 3.019, SD = 1.400), and speaking skills (mean = 2.961, SD = 1.386). Table 2 shows that 57.3% of the participants were still in the labor force, as opposed to 31.1% who were retired and 11.7% who were unemployed. Finally, regarding the type of employment the majority (53.4%) were civil servants while only 11.7% were private employees. A possible limitation of the study is the fact that

most participants were less than 65 years old, as well as the fact that most participants were graduates of higher educational institutions.

Table 1. Demographic data of the participants (n = 103).

	Frequency	Percentage (%)
Age		
55–64	81	78.6
65–74	19	18.4
75+	3	2.9
Gender		
Male	36	35
Female	67	65
Residence		
Civil Center	79	76.7
Providence	24	23.3

Table 2. Educational level and professional status of the participants.

	Frequency	Percentage (%)
Educational Level		
Not graduated from primary school	2	1.9
Primary school	16	15.5
High school	11	10.7
Higher education	74	71.8
Work Situation		
Working	59	57.3
Retired	32	31.1
Unemployed	12	11.7
Type of Employment		
Civil Servant	55	53.4
Private Employee	12	11.7
Freelancer	10	9.7
Housekeeping	16	15.5
Other	10	9.7

3.3. Measures

The method used for the present study included a literature review, containing relative articles from the last 15 years, as well as an online survey by means of a questionnaire. The literature review was based on published studies from IEEE, dblp, ERIC, Elsevier, CiteSeerX and PsycINFO. For the online survey, an online questionnaire platform was used in order to develop a questionnaire exploring the perception, attitudes and level of familiarity of older adults (55+) with ICTs. The questionnaire (Appendix A), which consisted of 24 questions in Greek (ten multiple-choice, nine Likert scale, four dichotomous and one check-box), was divided into the following categories:

1. Demographic Questions
2. Familiarization to Information and Communication Technologies
3. Learning Approach
4. Specifications of e-learning modules

4. Results

The structural validity of the questionnaire was guaranteed by measuring the strength of correlation between individual results. For this, Pearson's correlation coefficients were calculated for questions related to participants' attitudes toward the preferred learning approach to the e-learning modules (Table 3), as well as for questions related to the specifications of the modules (Table 4).

As shown, all correlation coefficients were moderate to high and statistically significant at the 0.01 level, proving the validity of the questionnaire used for data collection. In addition, for the internal reliability of the questionnaire, Cronbach's Alpha coefficient was calculated. For the eight items related to the preferred learning approaches, Cronbach's Alpha was 0.892, while for the six items related to the specifications of the e-learning modules it was 0.895. The overall Cronbach's Alpha was 0.926, indicating the reliability of the questionnaire.

Table 3. Bivariate correlation between the questions related to the learning approach.

	1	2	3	4	5	6	7	8
1. Autonomous learning modules	1.000							
2. Grouping relevant modules	0.429 **	1.000						
3. Continuity between modules	0.620 **	0.658 **	1.000					
4. Step by step presentation	0.587 **	0.521 **	0.636 **	1.000				
5. Exercises after each session	0.563 **	0.379 **	0.635 **	0.667 **	1.000			
6. Questions during the modules	0.527 **	0.319 **	0.581 **	0.621 **	0.832 **	1.000		
7. Scores on each assessment	0.563 **	0.388 **	0.460 **	0.446 **	0.552 **	0.542 **	1.000	
8. Assessment after each session	0.511 **	0.364 **	0.423 **	0.488 **	0.543 **	0.487 **	0.452 **	1.000

** Correlation is significant at the 0.01 level.

Table 4. Bivariate correlation between the questions related to the specifications of e-learning modules.

	1	2	3	4	5	6
1. Comprehensive and short modules	1.000					
2. Examples	0.425 **	1.000				
3. Descriptions of definitions and terms	0.342 **	0.724 **	1.000			
4. Graphics	0.422 **	0.807 **	0.691 **	1.000		
5. Explanatory videos	0.424 **	0.662 **	0.600 **	0.824 **	1.000	
6. Revision after units	0.408 **	0.582 **	0.693 **	0.692 **	0.773 **	1.000

** Correlation is significant at the 0.01 level.

Questions 9 through 21 targeted the familiarization of older adults with information and communication technologies (Table 5). According to the results, participants were more confidence in their use of simple mobile phones (mean = 3.952, SD = 0.984) and personal computers or laptops (mean = 3.573, SD = 1.411), in comparison to the use of smartphones (mean = 3.301, SD = 1.441) and tablets (mean = 272, SD = 1.422). Older adults seemed to be more confident when they used a keyboard (mean = 3.971, SD = 1.256) and a mouse (mean = 3.845, SD = 1.239) rather than using a touch screen (mean = 3.678, SD = 1.239). The majority of the participants (79.6%) used the Internet every day, while only a mere 4.9% did not use the Internet at all. However, only 41.7% of the participants reported feeling confident while using the Internet.

Most participants (35.9%) learned how to use information and communication technologies from their family environment, while 29.1% of the participants were self-taught. It must be mentioned that almost 20% of the participants actually attended ICT classes in an ICT school. In addition, the majority of the participants (77.7%) stated that they have an e-mail account, while, notably, 9.7% stated that they are not sure whether they have an e-mail account or not. Moreover, 73.8% of the older adults participating in the online survey had experience in submitting electronic forms, while almost 4% stated that they were not sure if they had or not. Finally, the vast majority (91.3%) of the participants had used an online search engine at least once.

According to their responses, older adults seemed to spend more time searching for information on the Internet (mean = 3.398, SD = 1.174), sending and receiving e-mails (mean = 2.796, SD = 1.424), and reading the news (mean = 2.767, SD = 1.139) while online. In contrast, they did not spend much time e-shopping (mean = 1.757, SD = 1.071) or e-banking (mean = 1.971, SD = 1.256). In reference to mobile applications, older adults felt more confident when they used mobile devices for calling (mean

= 4.078, SD = 1.326), sending and receiving text messages (mean = 3.660, SD = 1.525), checking the time (mean = 3.553, SD = 1.551), and for web browsing (mean = 3.495, SD = 1.553).

Table 5. Familiarization of older adults with information and communication technologies.

	n	mean	SD
Frequency of Use of Online Activities			
News	103	2.767	1.139
Internet Search	103	3.398	1.174
Chat and Social Media	103	2.466	1.274
E-Mail	103	2.796	1.424
Entertainment	103	2.495	1.220
E-Shopping	103	1.757	1.071
E-Learning	103	2.282	1.294
E-Banking	103	1.971	1.256
E-Government	103	2.243	1.356
Confidence on Mobile Applications			
Calls	103	4.078	1.326
Text Messages	103	3.660	1.525
Web Browsing	103	3.495	1.533
E-Mail	103	3.126	1.678
Social Media	103	2.621	1.652
Games	103	1.922	1.334
Alarm Clock	103	3.252	1.643
Clock	103	3.553	1.551
Calculator	103	3.233	1.567
Reminders	103	2.777	1.639
Notes	103	2.476	1.558
Maps	103	2.922	1.576

Table 6 represents the confidence level of the participants while using the Internet, in terms of their gender, age, residence and educational level.

Table 6. Impact of demographic characteristics and educational level on participants' confidence towards the use of the Internet.

Characteristic	Not at All	Usually Need Help	Depends on the Use	Feel Confident	Chi Square Test
Gender *n*(%)					$x^2(3) = 4.307$
Male	1(2.8)	3(8.3)	13(36.1)	19(52.8)	$p = 0.230$
Female	8(11.9)	5(7.5)	30(44.8)	24(35.8)	$\varphi = 0.204$
					$n = 103$
Age *n*(%)					$x^2(6) = 7.441$
55–64	7(8.6)	4(4.9)	34(42)	36(44.4)	$p = 0.282$
65–74	2(10.5)	4(21.1)	8(42.1)	5(26.3)	$\varphi = 0.269$
75+	0(0)	0(0)	1(33.3)	2(66.7)	$n = 103$
Residence *n*(%)					$x^2(3) = 4.364$
Civil Center	6(7.6)	4(5.1)	35(44.3)	34(43)	$p = 0.225$
Providence	3(12.5)	4(16.7)	8(33.3)	9(37.5)	$\varphi = 0.206$
					$n = 103$
Educational Level *n*(%)					
Not graduated from primary school	0(0)	1(50)	1(50)	0(0)	$x^2(9) = 26.990$
Primary school	5(31.3)	2(12.5)	8(50)	1(6.3)	$p = 0.001$
High school	1(9.1)	2(18.2)	4(36.4)	4(36.4)	$\varphi = 0.512$
Higher education	3(4.1)	3(4.1)	30(40.5)	38(51.4)	$n = 103$

A chi-square test of independence was performed, in order to examine the impact of gender, age, residence and educational level on older adults' confidence towards the use of ICTs. The relation between the level of confidence using ICTs and the educational level was significant ($x^2(9) = 26.990$, $p = 0.001$). More educated older adults were more confident with ICTs than their peers with lower educational levels.

In terms of the learning approach used for the design of the e-learning modules (Table 7), older adults were more positive regarding the step-by-step presentation of the educational content (mean = 4.301, SD = 0.895), the existence of exercises after each module (mean = 4.291, SD = 0.788), and the existence of assessment tests after the completion of each e-learning module (mean = 4.194, SD = 0.852).

Table 7. Older adults' attitudes towards the preferred learning approach and the specifications of the e-learning modules.

Participants' Attitudes	*n*	mean	SD
Learning Approach			
Existence of specialized/autonomous e-learning modules	103	4.029	0.954
Grouping of the relevant e-learning modules	103	3.913	0.941
Continuity between the content of the modules	103	4.107	0.839
Step-by-step presentation of the content of the modules	103	4.301	0.895
Existence of exercises after each session	103	4.291	0.788
Existence of practice questions during the modules	103	4.185	0.905
Availability of scores on each assessment test	103	3.563	1.265
Existence of assessment test after each e-learning module	103	4.194	0.852
Specifications of Modules			
Modules to be comprehensive and short	103	4.155	0.998
The modules to include examples	103	4.524	0.778
Descriptions for definitions and terms in the modules	103	4.252	0.947
Utilization of special graphics for the design of modules	103	4.447	0.905
Utilization of explanatory videos in the modules	103	4.437	0.788
Existence of revision after the completion of a module	103	4.388	0.910

One-way analysis of variance (ANOVA) was applied in order to identify which factors could significantly affect participants' attitudes. According to the results, there was a significant relationship between the participants' educational level and their attitude towards the existence of specialized/autonomous modules in the e-learning platform $F(3, 99) = 3.527$, $p = 0.018$, $\eta^2 = 0.097$). Older adults who had graduated from high school had the most positive attitudes (mean = 4.182, SD = 0.603), while participants who had graduated from primary school had the least positive attitudes (mean = 3.375, SD = 1.147). In addition, the type of employment seemed to significantly affect older adults' attitudes regarding the learning approach used ($F(4, 98) = 3.048$, $p = 0.021$, $\eta^2 = 0.111$). Freelancers seemed to express more positive attitudes towards specialized/autonomous modules (mean = 4.500, SD = 0.707) compared to private employees (mean = 3.250, SD = 1.138).

There was also a statistically significant relationship between the attitude, the level of confidence while using the Internet, the existence of autonomous modules ($F(3, 99) = 4.471$, $p = 0.005$, $\eta^2 = 0.119$), the grouping of relevant modules $F(3, 99) = 4.299$, $p = 0.007$, $\eta^2 = 0.115$), and the continuity between modules $\left(F(3, 99) = 2.938, p = 0.038, \eta^2 = 0.082\right)$. In particular, participants who were confident about the use of the Internet had more positive attitudes regarding the existence of specialized/autonomous modules M(4.349, SD = 0.897), the grouping of relevant modules (mean = 4.279, SD = 0.826), and the continuity between modules (M = 4.372, SD = 0.817). This was in comparison with their peers who did not feel confident at all while using the Internet (mean = 3.222, SD = 1.394; mean = 3.444, SD = 1.333; and mean = 3.667, SD = 1.414, respectively).

In reference to the specifications of the modules, older adults were more positive towards the existence of examples in the modules (mean = 4.524, SD = 0.778), as well as to the utilization of special graphics (mean = 4.447, SD = 0.905) and explanatory videos (mean = 4.437, SD = 0.788). The results

revealed a significant relationship between the work situation and the attitudes towards the existence of revision after the completion of a module ($F(2, 100) = 3.914,\ p = 0.023,\ \eta^2 = 0.073$). Unemployed participants had more positive attitudes (mean = 4.833, SD = 0.389) compared to their peers in the labor force (mean = 4.186, SD = 1.042).

5. Discussion

The present study concerns literature and field study regarding older adults and new technologies, with emphasis on e-learning. The principle objective was to understand their cognitive characteristics and attitudes, as well as the way in which they learn best, in order to design and develop a suitable e-learning platform adapted to their needs. The results of the online survey targeting older adults, together with those already present in the literature review, allowed the following considerations.

As far as familiarization with devices is concerned, older adults seemed to be more confident using more "traditional" devices such as simple mobile phones and personal computers/laptops compared to smartphones and tablets. As a result, they also prefer using keyboards and mice over using touch screens. However, there are studies indicating that the use of touch screens instead of traditional input devices could reduce anxiety levels (Chung et al. 2010; Umemuro 2004). As far as mobiles are concerned, older adults mostly use them for calls, messages, checking the time, and browsing the Internet.

Concerning access to the Internet, the research indicated that only a minority of the participants does not use the Internet at all. Nevertheless, and aside from the fact that the vast majority appears to be online on a daily basis, less than half of them felt safe or confident while using Internet-based services. These findings are in accordance with recent studies on the use of the Internet by older adults (Choi and DiNitto 2013; Gatto and Tak 2008; Zickuhr and Madden 2012).

It appears that most participants learned how to use ICTs from their family environment, followed by the ones that were self-taught, whereas only one in five had actual computer and ICT training.

As far as the activities they engage in when they go online, older adults usually spend time searching for information (Wagner et al. 2010). This agrees with the fact that the vast majority of older adults state that they have used an online search engine at least once. Most of the participants also state that they have an email account and, in fact, sending and receiving emails was the second most common activity engaged in, followed by reading the news. Finally, older adults seem to still be very cautious with the use of e-shopping and e-banking (Xiong and Mathews 2005).

It appears that the level of education of older adults had a significant effect on their attitude towards use of and familiarization with ICTs. Higher educated participants seemed to be more confident compared to their peers with lower educational level, however, age, gender and residence did not have a significant effect.

As far as the learning approach of the e-learning course was concerned, participants considered the most important features to be the step-by-step presentation of the educational content and the existence of exercises and assessment at the end of each e-learning module.

The educational level as well as the type of employment of the older adult had a significant effect on their interest in specialized/autonomous e-learning modules. Participants with higher educational level seemed once again to be more confident and positive towards the autonomous modules compared to their peers with a lower education. The same applied to freelancers when compared with other types of employees.

Finally, the level of confidence while using the Internet had a significant effect on older adults' attitudes towards the existence of autonomous/specialized modules, as well as the grouping of relevant modules. Participants that felt more confident using the Internet in general were more positive towards the latter compared to their peers who did not feel confident in either.

6. Conclusions

The present study attempted to investigate the cognitive functioning, profile, learning needs, and familiarization of older adults with ICTs. The aim of this study was to reach a final didactical approach that could be adapted to the target group's learning needs. Older adults were more accustomed to using personal computers and/or laptops over mobile devices. In fact, in response to one question they clearly stated that they preferred using a keyboard and a mouse over touch screens. Hence, it was considered a certainty that the e-learning platform should be fully responsive and the creation of a mobile app should be considered.

The literature review revealed that the attention skills of older adults appeared very low, especially when multitasking. From this, the need for a simple graphical user interface (GCI) design, without using bright colors and excessive graphics, was established. In addition, a straightforward navigation design for the online modules would contribute to the elimination of distractors. Studies have revealed that aging is also correlated with a decline in cognitive procedures and, especially, in working memory. With aging, the brain changes, thus affecting executive function. However, it has been proven that participation in lifelong learning activities, along with intervention, can improve the cognitive skills of people and, consequently, their memory. Therefore, the e-learning modules should be short and comprehensive, breaking the educational material into small units. In addition, older adults find it hard to process large texts due to their deteriorating cognitive skills and to their growing anxiety, which comes as a consequence of age. Considering this, the learning modules should not contain much text in order to motivate older learners.

Studies have revealed that due to their lack of confidence and their growing anxiety, older adults prefer a more self-directed (or personalized-learning) approach (Reimann et al. 2012). This should be set in an informal learning setting with a flexible curriculum where they can follow the learning modules of their choice and at their own pace. An e-learning setting can provide such a setting by giving adequate time and space to repeat and absorb the newly acquired material, which is available anytime and anywhere. That being said, older adults sometimes appreciate the help of a peer or a teacher. Although they may be reluctant at first, studies show that older adults tend to make mistakes and at some stage will need support (Alonso et al. 2005), whether from a teacher or from a peer learner. An e-learning environment, which offers communication and social capabilities, can provide such a setting.

In regards to assessment procedures, the existence of exercises after the end of an online course is a practice that adults welcome, not so much to be marked but in order to understand their learning needs. In fact, they wish to have very clear learning goals set before they take a course. Therefore, an e-learning environment that provides an automated assessment system for self-evaluation, based on the successful completion of certain criteria, such as quizzes, comprehension exercises, practical questions, assignments, etc. could prove useful. It was clearly demonstrated in the field research that older adults showed positive attitudes towards the incorporation of practical exercises and assessment methods in general, both during and after the completion of an online module, which clearly shows that they prefer a more active and experience-based learning approach rather than a passive one. They preferred receiving feedback but not necessarily being marked. The reception of feedback can clearly contribute to better understanding of the material and the self-diagnosis of their learning needs. From the above, and based on the survey results, the conclusion that was drawn is that the target group prefers to spend time on practical-oriented learning material with examples and practical questions. In other words, they prefer to learn something that will be useful in their everyday lives and, apart from learning the theoretical background, they wish to put what they learned into practice. Therefore, learning content should not be isolated from its practical context. In order to achieve this, exercises that allow the target group to practice the newly acquired skills and knowledge should be provided.

Summing up, the learning modules hosted in the e-learning platform should be presented in a clear and logical way. Given the aforementioned cognitive limitations of older adults and based on the survey feedback, the overall conclusion is that the learning modules should have specific learning

goals, be short in length, using mostly multimedia over text. Step-by-step presentation is the preferred way to provide educational content to the target group in order to ease the learning process as much as possible.

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Appendix A. Questionnaire "Older Adults and New Technologies"

Appendix A.1. Demographics

Question 1: How old are you?

- 55–64
- 65–74
- 75+

Question 2: Gender

- Male
- Female

Question 3: Residence

- Civil Center
- Providence

Question 4: Education Level

- I have not graduated from primary school
- Primary School
- High School
- Higher Education

Question 5: Knowledge of English

	Not at All	Incomplete	Moderate	Good	Very Good
	1	2	3	4	5
Speaking					
Reading					
Writing					

Question 6: Current Work Situation

- Employee
- Retired
- Unemployed

Question 7: Employment

- Civil Servant

- Private Employee
- Freelancer
- Housekeeping
- Other

Question 8: You have difficulties in

	Never	A Little Bit	Moderate	Much	Very Much
	1	2	3	4	5
Vision					
Hearing					
Touch					

Appendix A.2. Familiarization with Information and Communication Technologies

Question 9: Which of the following types of technology do you have access to? (Choose all that apply)

- PC/Laptop
- Mobile Phone
- Smartphone
- Tablet
- None

Question 10: How would you rate your skills on the following?

	Not at all	Incomplete	Moderate	Good	Very Good
	1	2	3	4	5
PC/Laptop					
Tablet					
Mobile Phone					
Smartphone					

Question 11: Which of the following devices would you like to learn to better use?

	Not at all	A Little Bit	Moderate	Much	Very Much
	1	2	3	4	5
PC/Laptop					
Tablet					
Smartphone					

Question 12: Do you have someone to help you when you have questions while using the devices mentioned above?

- Yes
- No

Question 13: How often do you use the Internet?

- Everyday

- 2–3 times in a week
- Once a week
- 2–3 times a month
- 2–3 times a year
- Not at all

Question 14: How confident do you feel when using the Internet?

- Not at all
- Usually I need help
- It depends on the use
- I feel confident

Question 15: How did you learn to use ICTs?

- Family Environment
- Workplace
- Computer School
- Self-taught

Question 16: Do you have an e-mail account?

- Yes
- No
- I am not sure

Question 17: Have you ever submitted an electronic form?

- Yes
- No
- I am not sure

Question 18: Have you ever used an online search engine?

- Yes
- No

Question 19: How much time do you spend on the following online activities?

	Not at All	A Little Bit	Moderate	Much	Very Much
	1	2	3	4	5
News					
Internet Search					
Communication (Chat and Social Media)					
E-Mail					
Entertainment					
E-Shopping					
E-Learning					
E-Banking					
E-Government					

Question 20: How confident do you feel while using the following mobile applications?

	Not at All	A Little Bit	Moderate	Much	Very Much
	1	2	3	4	5
Calls					
Text Messages					
Web Browsing					
E-Mail					
Social Media					
Games					
Alarm Clock					
Clock					
Calculator					
Reminders					
Notes					
Maps					

Question 21: How confident do you feel when you use the following devices?

	Not at All	A Little Bit	Moderate	Much	Very Much
	1	2	3	4	5
Keyboard					
Touch Screens					
Mouse					

Appendix A.3. Learning Approach

Question 22: If you were attending an e-learning course, you would like:

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
	1	2	3	4	5
Specialized/autonomous learning modules					
Grouping relevant modules					
Continuity between the modules					
Step-by-step presentation of the modules					
Exercises after each session					
Questions during the sessions					
My scores on each assessment available					
Assessment after each session					

Appendix A.4. Specifications of E-Learning Modules

Question 23: If you were attending an e-learning course, you would like:

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
	1	2	3	4	5
Modules to be comprehensive and short					
Examples					
Descriptions for definitions and terms					
Graphics					
Explanatory videos					
Revision after units					

Question 24: Add a comment (Optional)

Thank You!

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