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E-Learning for Deaf Adults from a User-Centered Perspective

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Abstract: Deaf individuals present differences compared to their hearing peers in terms of their learning profile. In addition, deaf adults seem to still be socially excluded nowadays, given that the transition from school to work is more difficult for people with hearing loss. This study aims to analyze the cognitive characteristics of deaf adults, as well as the way they learn better, for the development of an innovative and user-friendly e-learning platform, which will be adapted to the educational needs of the target group. Fifty-three deaf or hard-of-hearing adults participated in the field research for the needs of this study. According to the results, participants prefer e-learning modules with continuity in terms of the content, which offer comprehension questions during the sessions, as well as practice exercises after their completion. Furthermore, participants had positive attitudes towards the use of special graphics and explanatory videos.

Keywords: deaf cognition; e-learning; hard of hearing; deaf learners

1. Introduction

Social exclusion of deaf or hard-of-hearing (from now on "deaf") has been driven from various factors, such as educational and economic policies, social welfare regulations and attitudes of people in society [1,2]. There is evidence that transition from school to work is harder for the deaf, especially for those who do not have access to further education [3]. Despite the fact that the number of deaf students attending universities and colleges has increased, there are still barriers towards access of deaf to higher education [4]. Lack of interest for college, generally negative attitudes toward education, anxiety and poor study habits are considered as the main factors which could result in dropping out of college for deaf individuals [5]. In addition, the lack of independent living skills, such as maintaining home responsibilities, could reduce the sense of independence, as well as the self-esteem of deaf adults [6].

In 1948, the first Association of Deaf was established in Greece, while 21 years later it was followed by the *Greek Federation of Deaf*. Today, there are 19 deaf organizations active in Greece [7]. The inclusion of students with special educational needs is the main educational policy in Greece [8] as a means of inclusion of adults with special needs in employment. Recent institutional changes in Greece in relation to special education influenced directly the education of deaf children. Deaf students can attend mainstream schools, provided that specialized educational staff (special education teachers) is available. However, it should be mentioned that the perspective of inclusion as simply the enrollment of disabled to mainstream schools is not enough, as a broader view of inclusion is required in order to improve the educational outcomes of the deaf [9].

Lifelong learning seems to constitute a crucial parameter against social exclusion of deaf adults. In this study, we examine and analyze the way that deaf adults learn, the cognitive profile of deaf individuals, as well as how information and in particular, educational content should be presented to them, in order to develop an innovative and user-friendly e-learning platform that fully responds to the educational needs of the target group, as well as to bridge the existing social, educational, and technological gaps.

2. Literature Review

2.1. Differences in Cognitive Functioning between Deaf and Hearing Individuals

The design of an effective e-learning platform for deaf people should be implemented in accordance with the specific educational needs, as well as the learning profile of the target group. For this reason, it is necessary to investigate the main differences in cognitive functioning between deaf and hearing individuals.

2.1.1. General Cognitive Profile

The mean IQ score of the deaf is comparable to hearing individuals and tends to increase over time [10]. However, deaf individuals show differences in comparison to their hearing peers, in terms of their memory, problem-solving skills and academic achievement [11]. Visual communication skills of deaf people, such as visual language processing, present individual cognitive differences. It has been reported that deaf and hearing individuals have the same level of visual contrast sensitivity [12]. Phonological quality and precision, access speed to long-term memory, degree of explicit processing, and general storage capacity are the main parameters which interact for language understanding [13]. Furthermore, deaf children appear to have impairments on fine motor sequencing skills, despite the fact that their visuospatial cognitive abilities are not significantly different compared to their hearing peers [14].

2.1.2. Attentional Skills

Attentional skills are considered as crucial for everyday activities of deaf individuals, as identification of peripheral visual signs is more important for them, due to hearing loss [15]. Hearing loss is not considered as a predictive factor of attentional deficits, as deaf individuals perform the same with their hearing peers and sometimes better when dealing with attention-demanding tasks [16]. However, there is evidence for significant differences in visual attention between hearing and deaf individuals, especially in peripheral attention [17]. The study of Bavelier, Dye, and Hauser (2006) revealed that in contrast with their hearing peers, deaf individuals are more distracted by peripheral distractors and less by central distractors [18].

2.1.3. Working Memory

Early exposure to sign language seems to have a positive impact on deaf children's cognitive development, as well as on the mastery of visual perspectives [19,20]. On the other hand, there is evidence that differences in working memory tasks between deaf and hearing individuals arise from the fact that coding via sign language needs more space than spoken language [21]. Sign languages could negatively affect short term memory, because of their visuospatial nature, as well as their time-consuming production process [22,23]. It has been reported from fMRI (functional magnetic resonance imaging) studies that there are significant neural differences in verbal short-term memory for speech and sign language [24].

2.1.4. Reading Comprehension

Deaf individuals display low levels of reading skills, as they have a different way for recognition of words compared to hearing readers [25]. There is evidence that phonological coding and

awareness skills, as well as language ability, are related to the reading proficiency of the deaf [26]. Text comprehension of deaf adults is correlated with their reading motivation and, thus, a challenging reading material could improve their reading skills [27]. Domínguez and Alegria (2009) investigated the reading mechanisms that deaf adults use. Results showed that most participants used the keyword strategy, in order to understand a given text, which is consistent with the fact that deaf adults have a large orthographical lexicon [28]. In addition, there is evidence of serious difficulties in text composition by the deaf, as a result of the lack of auditory input and differentiations in their working memory [29].

2.2. E-Learning for Deaf

Distance learning or electronic learning (from now on e-learning) is a relatively new and untraditional instructive method to today's era of technology [30]. As a tool, it has facilitated educational processes for people around the globe [31]. The power of the Internet and, thus, e-learning, is based in its universality [32]. According to the World Wide Web Consortium (from now on W3C) the Internet was designed to work for all individuals regardless of their abilities and capacities. Subsequently, it must be accessible to people with a diverse range of hearing, sight, movement, and cognitive abilities.

According to the W3C, the effect of disability is fundamentally changed by the Internet since using it removes communication and interaction barriers that individuals may face in the physical world. This, highlights the need to provide opportunities for disabled people regardless of their disability, by making online services, and particularly e-learning, available to them in a way that respects and take into account their needs. It is not only a matter of equal human rights, but also a need for the disabled, and specifically deaf and hearing impaired people, to benefit from this technology and its advantages. Doing otherwise provokes the "digital divide" phenomenon, which opposes e-inclusion policies and actions, that have been heavily promoted and supported worldwide and especially through EU policies in the recent years [33].

Nevertheless, it appears that special educational needs of people with disabilities, such as deafness and partial hearing loss, are rarely taken into account when e-learning systems are developed [30]. It is true that designing interfaces that are suitable and user-friendly for them is not always an easy process [34]. This may be due to the fact that despite that the label "deaf people" suggests a homogeneity of characteristics and needs, that is not always true [35].

Depending on the type and level of deafness and the age a person lost his/her hearing, linguistic, and literacy skills may differ and also reading and writing skills may be affected. This raises issues when creating e-learning interfaces [36] making it difficult to develop educational prototypes. Designers of such systems must recognize and take into account the special needs that occur on both communicative and cognitive levels [37]. These needs can be addressed through the use of suitable e-learning and multimedia ICT tools, which can enhance teaching and learning by offering interactivity and multiple representations for learning processes [38].

Deaf persons have a special talking language [39], sign language, which uses manual communication, body language and lip patterns instead of sounds [31]. It is necessary, when designing e-learning systems for deaf and hearing impaired individuals, to provide all audio in a visual way using text, subtitles, pictures, and sign language videos and also to create a graphical interface that is effective and understandable presenting educational activities in a logical and effective way for them [38]. Having said that, use of text should be kept to a minimum since deaf and hearing impaired people present to a certain extent, difficulties in reading comprehension.

For example, studies show that deaf people who use sign language process images easier and more efficiently compared to words [40]. The designer and developer of an e-learning system for deaf and hearing impaired learners must take the aforementioned parameters, as well as principles and guidelines by the Web Accessibility Initiative of the World Wide Web Consortium into account in order to create a useful and motivational e-tool for them.

According to the state-of–the-art, most important instructional methods in e-learning include use of examples, practice questions and feedback [41], as well as short and comprehensive micro-modules [42]. Straetz et al. presented a learning management system (LMS) for adults in Germany, which offered videos in German Sign Language [43]. In addition, the learning system for deaf adults presented in the DELFE project included videos in Greek Sign Language, text and special graphics for the presentation of the educational material [33].

3. Method

3.1. Materials

The first stage of the research included a literature review in order to present the state-of-the-art in terms of the cognitive functioning, as well as the e-learning systems for deaf adults.

As far as the online survey is concerned, a questionnaire for adult deaf and hard of hearing individuals was designed (Appendix A), based on the principles stated by the state-of-the-art on this topic, and was transferred to an electronic questionnaires platform. The online questionnaire consisted of 13 questions, divided into four sections:

- Demographic Characteristics
- Access to Information and Communication Technologies
- Learning Approach
- Specifications of modules and e-learning platform

Regarding the type of questions, there were five multiple choice questions, four Likert scale questions, two dichotomous questions, one open-ended, and one check-box.

3.2. Procedure

The purpose of this study was to investigate the way that deaf and hearing impaired people learn, as well as to analyze how information and educational content should be presented to them in order to achieve the optimal learning outcome. For this reason, the specific objectives of the study included the research on deaf adults' access to ICT, as well as on their attitudes towards the learning approach used and the specifications of the modules in the e-learning platform. The initial phase of the research consisted of the literature review, in order to record the state-of-the-art regarding deaf and hearing impaired learners. Based on the findings from the literature review, the online questionnaire was developed, which was subsequently sent massively to Greek deaf associations in the Athens region. For the data statistical analysis, the IBM SPSS Statistics Software was used (Armonk, New York, NY, USA), version 1.0.0.800.

3.3. Participants

The online questionnaire, was sent via e-mail to various Greek deaf associations, and was available for fifteen (15) days. Fifty-three (53) responses were collected for data analysis, consisting of 25 male (47.2%) and 28 female (52.8%) deaf or hard of hearing participants (Table 1). Most participants (43.3%) were aged from 26 to 35 years old, while the fewer participants (8) came from the 46–55 age group. Most of the participants (30) were hard of hearing with various levels of hearing loss, while the rest were deaf. A total of 23 participants (43.4%) had congenital hearing loss, while 30 participants (56.6%) had acquired hearing loss some time in their lifetime. In terms of the educational profile of the participants, 26 had attended special schools, while 23 had attended mainstream schools. The greatest percentage of the participants (69.8%) were graduates of Higher Education Institutions, while only a mere 3.8% (two participants) have graduated from a primary school (Table 2). Finally, in what regards their professional status 13 participants were unemployed while 22 were employed either in the public or private sector and only one participant was retired.

Table 1. Demographic data of the participants (n = 53).

	Frequency	Percentage (%)
Age		
18–25	11	20.8
26–35	23	43.4
36–45	11	20.8
46–55	8	15.1
Gender		
Male	25	47.2
Female	28	52.8
Type of Deafness		
Hard of hearing (<50%)	1	1.9
Hard of hearing (50–80%)	11	20.8
Hard of hearing (>80%)	18	34
Deaf	23	43.4
Cause of Deafness		
Congenital	23	43.4
Acquired	30	56.6

Table 2. Educational and professional status of the participants (n = 53).

	Frequency	Percentage (%)
Type of Education		
Special School	26	49.1
Mainstream School	23	43.3
Parallel Support	1	1.9
None of the above	3	5.7
Level of Education		
Primary Education	2	3.8
Secondary Education	8	15.1
Technical Education	6	11.3
Higher Education	37	69.8
Professional Status		
College Student	9	17
Employee in the public sector	12	22.6
Employee in the private sector	10	18.9
Freelancer	7	13.2
Retired	1	1.9
Housework	1	1.9
Unemployed	13	24.5

4. Results

For the internal consistency of the questionnaire, Cronbach's Alpha coefficients were calculated. Cronbach's Alpha coefficient for the questions related to the familiarization of the participants with ICTs was 0.895, for the questions related to the attitudes of the participants towards the learning approach it was 0.947, while for the questions related to the modules of the e-learning platform Cronbach's Alpha was 0.926. All the values advocate the reliability of the questionnaire used for data collection. In order to evaluate the structural validity of the questionnaire, the Pearson's correlation coefficients between questions of the questionnaire were calculated (Tables 3–5). Most coefficients were moderate or high, indicating the validity of the questionnaire used.

Table 3. Correlation coefficients between questions related to the use of ICTs.

	PC	Tablet	Smart-Phone	News-Blogs	Social Media	E-mail	Product Search	E-Shopping	E-Banking	E-Government	E-Learning	Entertainment
PC	1.000											
Tablet	0.490 **	1.000										
Smartphone	0.512 **	0.331 *	1.000									
News/Blogs	0.151	0.179	0.145	1.000								
Social Media	0.453 **	0.206	0.642 **	0.302 *	1.000							
e-mail	0.576 **	0.349 *	0.502 **	0.444 **	0.366 **	1.000						
Product search	0.336 *	0.373 **	0.531 **	0.234	0.356 **	0.521 **	1.000					
e-shopping	0.424 **	0.436 **	0.479 **	0.273 *	0.541 **	0.534 **	0.627 **	1.000				
e-banking	0.423 **	0.374 **	0.395 **	0.434 **	0.485 **	0.660 **	0.562 **	0.720 **	1.000			
e-government	0.578 **	0.518 **	0.312 *	0.399 **	0.413 **	0.636 **	0.417 **	0.670 **	0.725 **	1.000		
e-learning	0.396 **	0.294 *	0.088	0.399 **	0.234	0.510 **	0.221	0.543 **	0.467 **	0.681 **	1.000	
entertainment	0.363 **	0.241	0.149	0.142	0.209	0.310 *	0.461 **	0.428 **	0.189	0.483 **	0.392 **	1.000

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

Table 4. Correlation coefficients between questions related to the learning approach.

	Autonomous Learning Modules	Grouping Relevant Modules	Continuity between Modules	Step by Step Presentation of Modules	Exercises after Each Session	Questions during the Sessions	Assessment after Each Session
Autonomous learning modules	1.000						
Grouping relevant modules	0.702 **	1.000					
Continuity between modules	0.663 **	0.774 **	1.000				
Step by step presentation of modules	0.705 **	0.746 **	0.762 **	1.000			
Exercises after each session	0.571 **	0.733 **	0.759 **	0.826 **	1.000		
Questions during the sessions	0.594 **	0.704 **	0.777 **	0.886 **	0.839 **	1.000	
Assessment after each session	0.611 **	0.633 **	0.598 **	0.755 **	0.657 **	0.772 **	1.000

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

Table 5. Correlation coefficients between questions related to the modules of the e-learning platform.

	Comprehensive and Short Modules	Examples	Descriptions for Terms	Graphics	Explanatory Videos	Videos in Sign Language	Revision after Units
Comprehensive and short modules	1.000						
Examples	0.623 **	1.000					
Descriptions for terms	0.560 **	0.850 **	1.000				
Graphics	0.575 **	0.913 **	0.794 **	1.000			
Explanatory videos	0.412 **	0.796 **	0.683 **	0.878 **	1.000		
Videos in sign language	0.356 **	0.470 **	0.418 **	0.561 **	0.684 **	1.000	
Revision after units	0.547 **	0.772 **	0.779 **	0.743 **	0.632 **	0.450 **	1.000

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

Questions 9 and 10 targeted the participants' access to Information and Communication Technologies (Table 6). According to the data analysis, smartphones seems to be the most useful devices for deaf and hearing impaired adults ($M = 4.264$, $SD = 1.137$), followed by personal computers (desktop PCs and/or laptops) ($M = 3.529$, $SD = 1.077$) and tablets, which seem to be the least useful device for them ($M = 2.359$, $SD = 1.346$). In terms of e-services, participants use more frequently social media ($M = 3.981$, $SD = 1.065$), e-mail ($M = 3.698$, $SD = 1.219$), and news/blogs ($M = 3.434$, $SD = 1.101$). On the other hand, participants spend less time for e-learning ($M = 2.245$, $SD = 1.329$), as well as for e-entertainment ($M = 2.472$, $SD = 1.250$), e-banking ($M = 2.755$, $SD = 1.555$), and e-government ($M = 2.755$, $SD = 1.343$).

Table 6. Access to devices and services, based on gender.

	Male (n = 25)		Female (n = 28)		Total (n = 53)	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Devices						
PC	3.680	1.108	3.393	1.166	3.529	1.137
Tablet	2.200	1.323	2.500	1.374	2.359	1.346
Smartphone	4.400	1.000	4.143	1.146	4.264	1.077
Services						
News/Blogs	3.400	1.108	3.464	1.138	3.434	1.101
Social Media	4.080	1.038	3.893	1.100	3.981	1.065
e-mail	3.680	1.345	3.714	1.117	3.698	1.219
Product Search	3.640	1.186	3.071	1.331	3.340	1.285
e-shopping	3.120	1.394	2.821	1.416	2.962	1.400
e-banking	2.920	1.706	2.607	1.423	2.755	1.555
e-government	2.640	1.381	2.857	1.325	2.755	1.343
e-learning	2.040	1.136	2.429	1.476	2.245	1.329
entertainment	2.520	1.159	2.429	1.345	2.472	1.250

In order to find possible differences between groups in terms of participants' access to devices and ICT services, as well as their attitudes towards the learning approach and the specific educational modules of the e-platform, a one-way analysis of variance (ANOVA) was applied.

The main gender-based differences between groups were observed on the time spent on product search $\left(F(1,51) = 2.668,\ p = 0.109,\ \eta^2 = 0.050\right)$, as well as on the previous e-learning experience $\left(F(1,51) = 1.131,\ p = 0.292,\ \eta^2 = 0.022\right)$. However, none of these differences was statistically significant. In terms of the cause of deafness, participants who lost their hearing after birth, spent much more time on product search compared to their congenital peers, but without significant differences $\left(F(1,51) = 3.805, p = 0.057,\ \eta^2 = 0.069\right)$.

There was a significant effect of age as to the time spent on news sites and blogs ($F(3,49) = 3.995$, $p = 0.013$, $\eta^2 = 0.197$) as participants aged 26–35 spend more time on these e-services ($M = 3.826$, $SD = 1.029$) while participants from 18 to 25 spend the least time ($M = 2.546$, $SD = 1.214$). In addition, results indicated a significant impact of age on the use of e-banking $F(3,49) = 3.268$, $p = 0.029$, $\eta^2 = 0.167$), stating that deaf adults prefer e-banking mostly at the age from 36 to 45 $M = 3.364$, $SD = 1.433$), as well as a significant impact of professional status on the same e-service $\left(F(6,46) = 2.410,\ p = 0.041,\ \eta^2 = 0.239\right)$ given that freelancers seem to use e-banking most frequently ($M = 4.286$, $SD = 1.254$). Finally, participants with higher education, seem to use e-mail more often ($M = 3.973$, $SD = 1.118$), compared to their peers who received technical education ($M = 2.667$, $SD = 1.211$), indicating the significant effect of the educational level over the use of e-mail frequency.

In question 11, participants were asked to indicate the specific learning approach they would prefer, when attending an e-learning course (Table 7). As indicated by the data analysis, continuity between the different modules the existence of exercises after each session ($M = 3.906$, $SD = 0.904$), as well as the existence of practice questions during each module ($M = 3.887$, $SD = 1.050$) were

considered as the most important features by the participants. These were closely followed by the step by step presentation of each module ($M = 3.868$, $SD = 1.038$), the grouping of relevant modules ($M = 3.774$, $SD = 1.050$), the existence of some sort of assessment after each module ($M = 3.774$, $SD = 0.869$) and, finally, the existence of autonomous learning modules.

Table 7. Descriptive statistics on the attitudes towards learning approach.

	N	*Mean*	*SD*
Specialized/autonomous learning modules	53	3.660	0.831
Grouping relevant modules	53	3.774	0.954
Continuity between the modules	53	3.906	0.883
Step by step presentation of the modules	53	3.868	1.038
Exercises after each session	53	3.906	0.904
Questions during the sessions	53	3.887	1.050
Assessment after each session	53	3.774	0.869

There was a significant effect of age concerning attitudes towards the use of questions during each module ($F(3,49) = 2.708$, $p = 0.048$, $\eta^2 = 0.142$), given that participants aged 36–45 showed increased interest on this feature ($M = 4.182$, $SD = 0.751$) while participants aged 46–55 showed the least interest ($M = 3.250$, $SD = 1.035$). In addition, the percentage of hearing loss seems to affect participants' attitudes towards the existence of specialized/autonomous learning modules in the platform ($F(3,49) = 2.993$, $p = 0.040$, $\eta^2 = 0.155$), as participants with hearing loss levels from 50% to 80% had significantly different attitudes ($M = 4.000$, $SD = 0.632$) in comparison to deaf participants ($M = 3.348$, $SD = 0.935$). Finally, attitudes of participants towards the existence of exercises after each module, were significantly affected by their educational level ($F(3,49) = 3.265$, $p = 0.029$, $\eta^2 = 0.167$), considering that graduates from higher educational institutions had a more positive attitude ($M = 4.108$, $SD = 0.737$) towards these exercises than participants with technical education ($M = 3.000$, $SD = 1.095$).

In question 12, participants were asked to indicate the specifications of the e-learning modules they consider as most useful (Table 8). According to the responses, the utilization of special graphics in the modules seems to be the most desirable ($M = 4.170$, $SD = 0.995$), as well as the existence of coherent examples ($M = 4.076$, $SD = 0.917$) and explanatory videos ($M = 3.981$, $SD = 0.951$). Then follow the existence of descriptions for definitions and terms in the modules ($M = 3.887$, $SD = 0.974$), the existence of revision after each learning unit ($M = 3.868$, $SD = 1.020$), the utilization of videos in sign language ($M = 3.679$, $SD = 0.996$) and the existence of short/comprehensive modules ($M = 3.585$, $SD = 0.865$).

Table 8. Descriptive statistics on the attitudes towards the specifications of the modules of the e-learning platform.

	N	*Mean*	*SD*
Modules to be comprehensive and short	53	3.585	0.865
Examples	53	4.076	0.917
Descriptions for definitions and terms	53	3.887	0.974
Graphics	53	4.170	0.995
Explanatory videos	53	3.981	0.951
Videos in sign language	53	3.679	0.996
Revision after units	53	3.868	1.020

There was a significant effect of the cause of deafness, on participants' attitudes towards the utilization of videos in sign language ($F(1,51) = 4.834$, $p = 0.032$, $\eta^2 = 0.087$), as well as on the attitudes towards the use of graphics ($F(1,51) = 3.908$, $p = 0.049$, $\eta^2 = 0.071$). The viewpoint that modules need to be short, seems to be affected by the educational level of the participants,

as there were significant differences $\left(F(3,49) = 4.077,\ p = 0.012,\ \eta^2 = 0.200\right)$, especially between participants from higher education $(M = 3.784,\ SD = 0.712)$ and those from technical education $(M = 2.667,\ SD = 1.211)$. In addition, level of education affected attitudes towards the existence of examples during each module $\left(F(3,49) = 2.954,\ p = 0.042,\ \eta^2 = 0.153\right)$, the existence of descriptions for definitions and terms $\left(F(3,49) = 4.239,\ p = 0.010,\ \eta^2 = 0.206\right)$, as well as the existence of revision after each module $\left(F(3,49) = 7.942,\ p = 0.000,\ \eta^2 = 0.327\right)$.

5. Discussion

The present paper concerns an exploratory study regarding deaf and hearing impaired individuals and new technologies with emphasis on e-learning. The principle objective was to understand their cognitive characteristics and attitudes, as well as the way they learn better, in order to design and develop an e-learning platform that is suitable for them and adapted to their needs. The results of the online survey analysis targeted at deaf and hearing impaired people, together with those already present in the literature review, allow for the following considerations.

As far as access to Information and Communication Technologies (ICTs) is concerned, the study indicated that deaf and hearing impaired individuals seem to prefer smartphone devices compared to personal computers or tablets [44]. When online, deaf users, tend to engage mostly on social media [45], e-mail and reading news and blogs, whereas more rarely they spend time on e-learning activities, e-banking, entertainment and e-government services.

Concerning internet access and use of devices and services, no significant differences were found based on the gender of deaf and hearing impaired individuals. These results are in contrast with studies stating that men with hearing loss are more confident with ICTs compared to women [46,47]. Moreover, the study indicated no significant differences between congenital deaf participants compared with those who lost their hearing after birth. However, age and professional status seemed to have a significant effect on the e-services preferred, as well as the amount of time spent on them. Finally, the participants' educational level seemed to have a significant effect mostly in terms of e-mail usage.

As far as the learning approach of the e-learning course is concerned, all features questioned are considered important by the target group. Participants consider as the most important features the continuity between the different modules as well as the existence of questions and exercises during and after each module.

Age and educational level of deaf and hearing impaired participants have a significant effect on their interest on self-evaluation methods such as practice questions and exercises during and after each module. Furthermore, hearing loss percentage affects the acceptance of specialized/autonomous modules as participants with partial hearing loss seem to be more positive towards them compared to their deaf peers.

Special graphic utilization and existence of examples as well as explanatory videos are considered the most important features for the e-learning modules. Description of definitions and terms, revision after each module, use of videos in sign language and short duration of modules are also considered quite important.

The cause of deafness had a significant effect towards the utilization of videos in sign language and graphics to the e-learning modules. Moreover, the educational level of participants affects the desired length of the modules as participants with higher education prefer shorter modules compared to their technical education peers, as well as the existence of examples, descriptions of definitions and terms, and revision at the end of each module.

6. Conclusions

Section 508 Amendment of the US Rehabilitation Act of 1973 encouraged Federal agencies to eliminate barriers to Information and Communication Technologies for people with disabilities [48]. The present study attempted to investigate the cognitive functioning and profile, the learning needs and the familiarization with ICTs of deaf and hard of hearing adults. The field research showed

that deaf and hearing impaired adults feel more confident when using smartphones over personal computers or tablets. Hence, the e-learning platform should be at least fully responsive and the possibility of the creation of a mobile app as a complementary tool should be considered.

The literature review showed that deaf people possess in general good attentional skills, but can easily be distracted by visual peripheral distractors due to their hearing loss. Easy accessibility to the online modules through a straightforward navigation, could contribute to the elimination of distractions. In addition, deaf people show signs of low working memory capacity, as a result of sign language requiring more space compared to the spoken language. Therefore, learning modules should not be very long and an effort should be made in order to break down the learning content into short modules, which can be more easily followed by the target group. As referring to the reading skills, deaf people seem to find it difficult and quite unchallenging to read large amounts of text mainly due to differentiations in their working memory and to lack of auditory input. The latter is the main cause of their serious difficulties in text composition, too. Therefore, one of the main conclusions is that educational content should include as little text as possible and also use the key words strategy in order to catch the attention of learners. These conclusions are in accordance with the responses of the target group, where the presentation of the learning modules in a simple step-by-step way was a very popular choice. Using less text consequently means shorter (in length) learning modules, which is the approach that will be followed based on the aforementioned results. This approach will ease the learning process and also enhance motivation for the learners.

Studies have shown that information and content should be presented in a visual way to deaf and hearing impaired learners using images, videos with subtitles and, of course, sign language videos as they can process images and videos much more efficiently than words. Based on this, it is apparent that the educational material should also be provided in sign language videos as this is the optimum way to do so for these people.

In what regards assessment procedures, deaf adults had positive attitudes towards the existence of exercises after the end of an online course, in order to understand their learning needs. Given this, an e-learning platform addressed to deaf learners should provide an automated assessment system, based on certain completion criteria for self-evaluation.

According to the online survey results, participants expressed positive attitudes towards the continuity between the online modules. Based on this fact and together with the aforementioned conclusions that use of long texts should be avoided and that they have low working memory capacity, it is obvious that the modules should be short in length. The learning modules can be autonomous but at the same time they can relate to each other thus creating a complete learning module on a specific subject.

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Appendix A. Questionnaire: "Adults with Hearing Problems and E-Learning"

Appendix A.1. Demographics

Q1: How old are you?

- 18–25
- 26–35
- 36–45
- 46–55

- 55+

Q2: Gender

- Male
- Female

Q3: You are:

- Hard of hearing (<50%)
- Hard of hearing (50–80%)
- Hard of hearing (>80%)
- Deaf

Q4: You have lost your hearing:

- Congenital
- After your birth

Q5: Language (Check all that apply)

- Greek spoken
- Greek written
- Greek sign language

Q6: Education:

- Special school
- Mainstream school
- Parallel support
- None of the above

Q7: Level of Education

- Primary education
- Secondary education
- Technical education
- Higher education
- None of the above

Q8: Professional Status

- College student
- Employee in the public sector
- Employee in the private sector
- Freelancer
- Retired
- Housekeeping
- Unemployed

Appendix A.2. Access to Information & Communication Technologies

Q9: How often do you use the following devices?

	Never	Seldom	Sometimes	Often	Almost Always
	1	2	3	4	5
PC					
Tablet					
Smartphone					

Q10: How often do you use the following internet services?

	Never	Seldom	Sometimes	Often	Almost Always
	1	2	3	4	5
News/Blogs					
Social Media					
e-mail					
Product search					
e-shopping					
e-banking					
e-government					
e-learning					
entertainment					

Appendix A.3. Learning Approach

Q11: 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					
Assessment after each session					

Appendix A.4. Specifications of Modules and E-Learning Platform

Q12: 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					
Videos in sign language					
Revision after units					

Q13: Add a comment (Optional)

_____

_____

Thank You!

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