Involving older adults in the design process: a human-centric Design Thinking approach

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Abstract. A product's acceptance depends on the experience that it provides to its users. To consider user's contextualised specific needs an user-centred design process is recommended. Human-centric design considers human´s opinions as a design priority, and puts them in the "centre" of the iterative design process. To understand the end-users influence (adults 55+ experience) in product development, we conducted an empirical study with 25 participants, supported by a human-centric co-design thinking process (participatory design) with collection of qualitative data. In this article we report a Design Based Research (DBR) study, that compares the acceptance of a set of two audio-visual artefacts: designed with adults older than 55 and a design process supported only by the designer's expertise. Overall we believe this study depicts evidence that audio-visual artefacts for the online platform ICTskills4All are more effective when co-designed and validated with end-users.

Keywords: Co-design, Design Thinking, Digital Literacy, Older adults, User-Centred Design.

1 Introduction

The latest population projection report from the United Nations, The World Population Prospects 2019, indicates that the world population will continue to grow until the end of the 21st century, approaching 11 billion inhabitants. Increased average life expectancy, along with declining fertility -responsible for ever slower growth-, are the main phenomena responsible. In 2019 about 9% of the world population was 65 or older. It is estimated that this proportion of elderly people worldwide will reach about 16% in 2050, which means that 1 in 6 people in the world will be over 65 years old. In turn, the number of people over 80 appears to be growing at an even faster rate. In 1990, the number of people aged 80 and over was 54 million. This number has almost tripled by 2019 (143 million) and is projected to triple again by 2050, approaching 426 million [1].

Population ageing represents a serious challenge in the face of a society undergoing constant technological innovation. In the European Union, more than 35% of adults

55+ have never used a computer [2]. The low level of ICT (information and communication technologies) skills in this age group represents an important source of social isolation and exclusion in accessing information and services, such as managing tax obligations, banking transactions, online shopping, or even telecommuting [3]. The digital inclusion of adults 55+ allows mitigating these inequalities, contributing to greater autonomy, social participation and access to information. The direct and positive impact on mental health and cognitive domain is another added value [4]. Older adults interest and motivation in digital learning is very clear, especially when they perceive the benefits of its use [5]. The difficult access to digital instruction adapted to their characteristics and needs (age, geographical area, level of education, digital experience), constitutes a strong barrier in the learning process [6]. Understanding the preferences and user-experience of adults 55+ towards the digital world, with consequent adaptation of content, is crucial for the digital inclusion of this population [7].

Inclusion in one sense starts with the correct development of products for the final audience. A product's acceptance depends on the experience that it provides to its users. The product must meet the contextualised specific needs of the users, and one way to understand and consider those needs is through a user-centred design process. Human-centric design usually collects the user´s wishes, interests and needs [8] as a design priority, the element in the "centre" of the iterative design process.

As a contribution to the "user-centred design" paradigm, this study compares the acceptance of two audio-visual artefacts (A & B versions), designed with (A version) and without (B version) the influence of a participatory design (co-design) process [9], by older adults, the end-users of these products. The following sections: contextualise related work; detail the Design Based Research method [10]; the co-design thinking [11] procedure that was used to iteratively produce the two A version prototypes; B version prototypes; the A & B testing to compare the influence of the co-design process in the acceptance of the final audio-visual prototypes and a final section with the discussion and main findings, just before the conclusions and acknowledgements.

2 Related Work

The following sections detail our concerns on the "ageing and technology" relations and progress from a social perspective contextualised in state of the art scientific knowledge. Most of what technology can do to moderate ageing effects is directly related with the product design processes so one of the following sections reports our references on universal, Inclusive and Equity-focused Design. A last section will inform on our strategic references concerning Human-Centric Design.

2.1 Ageing and Technology

Concepts such as 'older adult' and 'senior' are nominal variables that can correspond to an age range between 50 - 65 [12]. The concept of 55+ adults emerges as a quantitative

marker, as a delimitation of behaviours, skills and recommendations of a specific population - adults aged 55 or over. When empathy for others' needs and wishes plays a key role in problem-solving we can broaden our comprehension of their user-experience [13]. Designing for the 55+ adults considers the loss of capacity consequent to ageing, such as: senses (vision, hearing, perception and balance), mobility (strength and reaction time) and cognition (forgetfulness and memorization) [14].

Vision is one of the senses that allows us to perceive our surroundings, but with ageing this capacity decreases. The main losses in the visual system are: the eye's ability to focus the image at close range; the perception and distinction of colours (namely green, blue and violet) [14]; reduced visual acuity, and consequently reduced visual adaptation to lighting changes - moving from bright to dark environments [15]. These losses may contribute to a reduction in the individual's ability to perceive non-verbal information in communication[16].

The auditory system contributes to the understanding of the outside world and to the person's balance in their movements [17]. Its main loss in ageing lies in the sensitivity and resistance to high-pitched sounds, with a lower sound being preferred to avoid discomfort in hearing [18]. The autonomy in controlling the volume and the decrease of the amount of sounds in the system, may contribute to a better use [19].

The loss of cognitive ability is directly related to the decrease in learning time and memory - decreased ability to retain information [20]. The main changes in the cognitive system are: difficulty in understanding long and/or complex messages to remember specific terms and to carry out reasoning activities involving unfamiliar material; reduced ability to perform new tasks and rapid psychomotor skills; memory impairment, especially memory related to the acquisition of new information; decreased attention span in multiple tasks (multitasking); difficulties in inductive behaviour, spatial orientation, in perception and numerical and verbal skills [21]. According to [22] from the age of 70 onwards there is a decline in intelligence. In this sense, functions that require the manipulation of new information are more problematic than those that require only the use of acquired knowledge.

The ageing process is also responsible for several motor alterations: slower response time to actions; decrease in the capacity to maintain continuous movement; disturbances in coordination and variability of movements and loss of flexibility. A clear understanding of these changes contributes to the identification of elements that can be implemented in technological development services. Usability studies show that newly designed technology such as mobile applications and smartphones are not meeting the expectations of older users [23]. Some older adults perceive technology to be difficult to learn and keep up. As a result, they tend to lose interest, and don´t make the necessary efforts to improve their ICT skills and end up avoiding new technology that they are not familiar with, relying on the support of younger family members or friends when they absolutely have to. This hinders them from fully taking advantage of their functions and services. It is imperative to know these biased perceptions to make an informed decision when designing a new technology product and also to get a different perspective by putting ourselves in the user's context of need. Readiness and willingness to adapt to new technology can sometimes be more difficult to overcome than physical or mental barriers. By designing in a more inclusive way, we can consider

the needs and capabilities of the whole population to decrease the gap between the user and the technology [24]. To increase older adults' engagement in technology, certain requirements and design interventions must be met. Some older adults do have certain cognitive and physical barriers that prevent them from using numerous technology-based solutions; however, their perceptions of technology are generally similar. By addressing the common sets of perceptions when it comes to the benefits and usage of technology, we can ensure that older adults are able to interact with digital technologies with more trust and confidence. The appropriate design can contribute to the inclusion of a greater number of users, facilitate access and use [25].

2.2 Universal, Inclusive and Equity-focused Design

When designing for a broader range of people, it's important to avoid the impulse to find one-solution-fits-all, the problem with one solution for everyone- Universal design- is that when you focus on creating a solution for everyone, the design loses its individual effectiveness. It's better to search for solutions that solve one and extend to many. Inclusive design provides equal access to everyone, regardless of identifiers like ability, race, economic status, language, age, and gender. The design process includes researchers and designers from traditionally excluded populations, so they can provide their unique perspectives during all phases of the design process. Equity-focused design takes this idea one step further. It fosters designers to focus on designing for groups that have been historically underrepresented or ignored when developing products [26], like 55+ adults when technology mediated solutions are at stake.

2.3 Human-centric Design

A product's acceptance depends on the experience that it provides to its users. The product must meet the contextualised specific needs of the users, and one way to understand and consider those needs is through an user-centred design process. Human-centric design collects the user´s opinions as a design priority, the element in the "centre" of the iterative design process. Focusing on the user means considering in the design process their story, opinions, behaviours, emotions, and the insights you have gathered from them. This theory believes that users are experts of their own lives and involving them can help improve the quality of the solutions and avoid ageist stereotypes [27]. User's also tend to engage more with products that they co-create and can be a useful source of creativity and innovation [28].

This study explores how end-user engagement can make a difference in actual design practice. Another important aspect of product usage is "context" mainly due to the fact that a user experience of a specific product is highly dependent on context. This is one of the main reasons inherent to the choice of the Design Based Research – DBR [10] paradigm for this study. It integrates iterative sequential cycles to inform the different research phases, with participatory research techniques and prototypes as research instruments. In fact this study is structured by 2 iterative DBR cycles with a

co-design thinking [11] prototype development in the first cycle and A & B prototype testing in the second DBR cycle.

To keep our focus on the user, the user-centred prototype design process of this work uses co-design thinking organised in four stages: empathise, define and pinpoint criticalities, ideate and prototype [29]. This approach helped us to develop the A version of the prototype with the participation of end-users and hopefully the procedure that best meets the user's needs and expectations. Larry Page, one of Google's founders, highlighted just how important user-centred design is when he said, "There is no substitute for personally watching and listening to real people" [30].

3 Method

To understand the end-users influence in the co-design and acceptance of a product, we conducted a 2 iterative cycle Design Based Research (DBR) study [10] with 25 participants and a prototyping process supported by a co-design thinking approach[11] with end-user qualitative data, as shown in figure 1. Design thinking is an iterative process and a user-centred approach for problem-solving [11] that considers in this study the end-user opinions, expectations and needs to nurture the double diamond [31] ideation exercise fostered by the dynamics of divergence and convergence thinking [32]. It helps designers create functional and affordable solutions that address well contextualised real user problems.

The second DBR cycle of this study (figure 1) includes the evaluation phase that compares the A and B versions of the two audio-visual artefacts, The A versions as an outcome of the participatory design thinking process and the B versions an integral and exclusive design exercise by the designer and principal researcher of this study. The A&B testing is performed empirically with a subset of participants that had undergone the first DBR iterative phase.

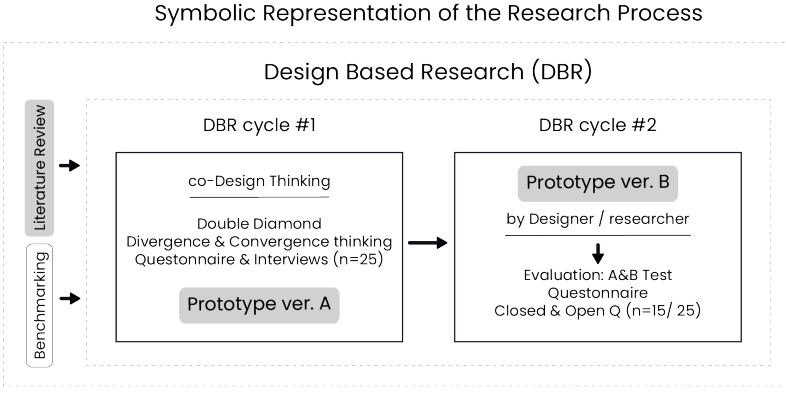

Fig. 1.. Symbolic representation of the research process phases depicting "grey shaded" elements that are detailed in this paper.

This study is incorporated in the ICTskills4All project [33], with the outcome of an online platform that aims to support the acquisition of digital skills among 55+ aged citizens. Participants were recruited with the help of APRe! [34], an ICTskills4All associated partner. The participants had reliable access to an internet connection at home which enabled them to participate freely and safely especially during the COVID-19 pandemic.

4 co-Design Thinking Procedure

Participants who were interested in participating in the study agreed to provide their contact details. They were also encouraged to invite other older adults within their own network who were likely to participate in the study. The respondents were between the age range of 55 - 81 years old (median=72). This sample integrates 25 participants, 16 (64%) female and 9 (36%) male, 88% (22/25) are already retired. We received consent for data collection and recording of the responses to the interview questions. The inclusion criteria for participants were as follows: 55 years or older; minimum technology skills to participate online, and open to share their personal opinions and interactions related to technology. Each participant volunteered and gave consent to integrate the study.

The first step in the design thinking [11] process is empathise. During the empathise phase we conducted interviews supported by a previously built questionnaire, aimed to understand users' different dimensions, to get a clear picture of who our users are and the challenges they are facing. These interviews took place virtually, on a video chat platform chosen by the participants for their comfort and familiarity. Most of the questions were presented in hypothetical scenarios, and inserted in the conversation, adapted to each user. Each interview was between 30 minutes and 3 hours depending on the participant and the flow of the interview; participants were encouraged to speak freely with a brief mediation of the interviewer.

After, the data was collected and transcribed into a spreadsheet. A qualitative analysis was conducted, all answers were tabulated, and eight categories were created (demographics, devices, digital experience, interaction & multimedia, online shopping & safety, pros & cons, education & learning, digital literacy) in order to group participants and to find similarities between the answers. For example, many participants admitted spending their time online watching videos. We created a category for video under the major grouping of multimedia and a category for interaction to understand if they were comfortable leaving feedback on those videos. For a holistic representation of the results, keeping detail of each category, we also created a quantitative table to show the frequency of a specific opinion of the participants in each category's sub-comments/ opinions.

This information was crucial for the next step: the define phase (identification of critical touchpoints). Based on our research findings we were able to create empathy maps and personas. We chose to build aggregated empathy maps to synthesise themes in the dimensions seen throughout the participants' comments and served as a first step

in the creation of personas. We clustered the users who exhibited similar attitudes, opinions and behaviours and assembled three personas - the conservative user, the moderate user and the liberal user. This tool was used to build a rich representation of the participants and increase empathy to the brainstorm exercise.

During the third step - ideation - we brainstormed solutions for the problem based on the tools built before. SCAMPER [35] method was used in a spreadsheet; the goal was to come up with as many design solutions as possible. The only constraint was the time limit, of a week, to keep the schedule moving forward. The new ideas not only focused on the content but also on improving the context where the users experienced the videos. For example, adapting the video player to be more accessible for older adult's needs.

Once this step was completed, we entered a more specific phase, the prototype. Here we focused on the functionality of the ideas that we had before, we prioritised the essential and reduced the clutter. We used the storyboard to preview the results and visually guided the construction of a model. This model helped us get a feel of what the product would look like and how users would experience it. This version of the prototype, 2 audio-visual (AV) artefacts, are identified in this study as A products, an outcome of the co-design thinking process. The B version of these AV artefacts were designed exclusively with the expertise, knowledge and perspective of the designer and researcher of this study.

4.1 Empathise: Analysis of adults 55+ experience

The respondents were between the age range of 55 - 81 years old (median=72). Regarding biological sex, 16 of them (64%) are female and 9 (36%) are male. Regarding the level of education, most of the respondents had at least a bachelor's degree (n=12; 48%). A few of them also had a masters (n= 3; 12%). Most of them are already retired (n=22; 88%).

All participants own a smartphone (n= 25; 100%). Most respondents own a laptop (n= 24; 96%) and a tablet (n= 13; 52%). Interestingly only a small number of respondents owned a desktop computer (n=7; 28%) and a few had access to a smartwatch (n=3, 12%).

All participants remember having their first contact with ICT in the latter half of their adult life (n= 25; 100%), with most associating the episode to their workplace (n= 21; 84%). When asked how they keep their ICT knowledge updated, more than half admitted to depend on the help of younger family members or friends (n= 15; 60%). Their digital consumer habits tend to be more focused on communication platforms such as Email (n= 25; 100%) and Facebook (n= 21; 84%). They also value news websites (n= 16; 64%) and use search engines (n= 13; 52%) like Bing and Google, reporting similarities to the Encyclopaedia they used to use and have. Very few reported having limitations regarding their digital experience, with most of them mentioning to feel insecure to explore new features that they are not familiar with (n= 6; 24%).

A little more than half of the participants are comfortable with commenting and interacting with online content (n= 14; 56%), while the other half admitted to rarely (n=

7; 28%) or never do it (n= 4; 16%). The participants reported having very little interest in non-educational/informative video content, mostly watching it for music (n= 10; 40%) or physical exercise purposes (n= 8; 32%). On the other hand, more than a half of the participants actively play games on their devices (n= 14; 56%).

Our research shows that a big part of the participants rarely (n= 8; 32%) or never (n= 10; 40%) shop online, mentioning how little benefit they see in it and most of them (n= 18; 72%) revealing safety concerns, like hackers/ scams / phishing, as the main reason to not do it. Even though the same number of participants (n= 18; 72%) trust their devices to consult and manage important personal documentation such as health and financial information. Other main safety concerns are: privacy (n= 14; 56%) and fake news (n= 12; 48%).

Almost all the participants listed "knowledge" (n= 22; 88%) and "communication" (n= 21; 84%) as the main pros of technology, followed by "facilitates" (n= 14; 56%) and "gives more options" (n= 12; 48%). The technology cons are more disperse with "hackers/ scams / phishing" (n= 18; 72%) and "lack of respect" online (n= 14; 56%) being the most mentioned. Other concerns mentioned by the participants are "time & dependency" (n= 13; 52%), worries about "shared content" (n= 10; 40%), "lack of control" (n= 5; 20%) and "human connection" (n= 5; 20%), promoting the "grey divide" (n= 4; 16%) and "excess of notifications" (n= 4; 16%).

When questioned about adult education institutions like senior universities, most reported not being a student in one (n= 20; 80%), even though half of the participants (n= 14; 56%) have at some point in the past attended adult learning. Less than half of the participants (n= 11; 44%) had a positive review about the subject.

One of the most interesting moments of the interview was asking about recommendations on how to teach ICT. Like the previous questions, this question was often asked as a hypothetical scenario "If you had to teach someone ICT/ how to use their ICT device, how would you do it?". The recommendations were varied, and even if some were more repeated than others, there is a lot of value in all of them. The main answer was to "talk slowly and show step-by-step" (n= 14; 56%), followed by "explaining how to communicate with friends and family"(n= 9; 36%). Other recommendations were: "interact with students"(n= 6; 24%), "create a need/ be very clear with the benefits" (n= 5; 20%), "teach how to organise the information" (n= 3; 12%), "understand what they already know and build from there" (n= 3; 12%), "congratulate and encourage a lot"(n= 3; 12%), "explain how difficult it is to make real damage to the devices" (n= 3; 12%),"explain enough so that the person really knows what she/he needs to buy" (n= 2; 8%) and last "be careful with font size"(n= 1; 4%).

The last category of the interview aimed at understanding the level of digital literacy of the participants, which was mostly revealed organically during the conversation. Based on the European digital literacy board [36] the participants were rated A (foundation) / B (intermediate) / C (advanced) on their knowledge in five different subjects: information and data literacy, communication and collaboration, creation of digital content, safety, and problem solving. Most of the participants rated A/ B in all subjects, with very few rating C.

4.2 Define: Identification of critical touchpoints

Empathy maps

Table 1. Empathy Map 1: Digital Literacy

Says	Thinks
"My first contact with ICT happened at work." "The company I worked for supported/ encouraged ICT learning through classes/ courses." "I keep up to date by using my devices on a day-to-day basis." "I ask my family and younger friends for help when I do not understand the device." "When I do not know something, I ask Google."	There was a professional need to learn ICT. The need for digital literacy was the biggest motivation to learn. To learn ICT after retirement, you need time to sit down and experiment. Younger people adapted better to new technology than older ones. ICT is resourceful. Is very aware of the amount of screen time he/she spends per day.
Does	**Feels**
Uses their devices to communicate every day. Uses Google as an encyclopaedia/ dictionary. Reads news online. Uses Facebook as the main social media network	Empowered. Satisfaction. Pride. Suspicious.

Table 2. Empathy Map 2: Devices

Says	Thinks
"I mainly use the smartphone for communication purposes and laptop for the rest." "If there is an attachment to the email, I have to use the laptop." "I have to update my devices every five years because the devices cannot handle the new programs."	Tablets are not helpful when already owning a smartphone and a laptop. Devices should suit their needs. The large number of possibilities their devices provide is a good thing. Technology moves fast and can be overwhelming.
Does	**Feels**
Uses a smartphone as the main device, and laptop as a second. Updates their devices every five years.	Grateful. Pleased. A little dependent. Overwhelming (notifications).

Table 3. Empathy Map 3: Interaction and Multimedia

Says	Thinks
“My first contact with ICT happened at work." "The company I worked for supported/ encouraged ICT learning through classes/ courses." "I keep up to date by using my devices on a day-to-day basis." "I ask my family and younger friends for help when I do not understand the device." "When I do not know something, I ask Google."	A Big Brother is constantly observing and controlling every online behaviour. It is not worth it to interact with online content unless it has a relevant contribution. Online games can help improve their mental health. The tablet format is perfect for playing games.
Does	**Feels**
Watches online videos with specific goals. Prefers people talking and active voice in videos. Trusts videos sent by friends. Mainly uses Youtube for watching short or/ and music videos and exercising. Trusts knowledge from educational videos.	Cautious Vulnerable Not in control of every action. Overwhelmed (with choices). More comfortable when the content is more humanised.

Table 4. Empathy Map 4: Online Shopping and Safety

Says	Thinks
"I prefer buying products in physical stores rather than online ones." "I feel more secure when I can associate a person (face) to the shop I am buying from." "I like to use it as an excuse to go outside." "I do not feel secure inserting my personal bank information online to buy things." "I am comfortable using government platforms and home banking." "I have some concerns with my privacy. I do not understand how my data is being used." "I trust the ATM completely." "I save my information in pens. I do not use the cloud."	Online shops are not transparent with their location, owner, details and quality of the products they sell. A certain degree of digital literacy is needed to perform an online purchase. Hackers/ phishing/ scams are the worst outcome that can happen. The cloud is difficult to understand. Products always look better in pictures online. Hotels, plane tickets and holiday-related bookings do not count as online shopping. Inserting personal data in government websites/ platforms is safe.

Does	Feels
Uses PayPal as a mediator for online shopping security. Bends their beliefs if they find a good deal online. Prefers to save the same information in several physical devices rather than use the cloud.	Insecure. Impersonal. Cautious. Exposed. Stress. Sceptical.

Table 5. Empathy Map 5: Advantages/ Disadvantages

Says	Thinks
“Thanks to technology, knowledge is much greater, and it is no longer possible to hide things." "I live alone, and the internet is my help for everything." "Technology has allowed us to have more freedom in the choices we make. It gives many options."	Knowledge and communication are the most potent tools that ICT provides. The ability to facilitate tasks that are harder without ICT is also a positive aspect. Living with ICT gives more options. ICT brings transparency to the world and empowers its users.
Does	**Feels**
Does not share pictures/ videos or personal information. Uses a third party when paying, like PayPal. Has defensive behaviour when asked for personal information. Controls the time and consumption of technology. Uses technology to improve their quality of life as long as technology serves their needs, not the other way round. (user has to feel in control). Uses technology as a facilitator for knowledge and communication. Relies on technology in their day to day routine.	Knowledge, communication are the main positive aspects for the users, followed by 'facilitating' and 'more options'. Hackers/ phishing/ scams and lack of respect online are the most negative for the users, followed by privacy concerns (data sharing) and dependency. Fearful about losing control and technology taking over.

Table 6. Empathy Map 6: Education and Learning

Says	Thinks
"Senior University is directed to a particular elderly public." "No one goes to a Senior University to learn about an academic subject."	(about Senior University) The principal praises are about the diversity of activities, social

"The courses' hybrid regime (online and on-site) are very advantageous." "It is not easy to learn about ICT." "I enjoy when my cousin explains me things, she is younger."	gatherings and organised visits outside the institution. (about Senior University) The main complaints are related to the lack of learning and evaluation like an academic institution. (about Courses) They like the online versions, some have attended these courses, they consider them a great alternative to the on-site modalities, but they prefer the latter. (about Courses) A few participants think they are too busy/ too tired mentally to attend a course and learn a new skill. (about learning ICT) The main recommendation focuses on explaining slowly and step by step, approaching the communication issue first.
Does	Feels
Most of the participants do not attend a senior university. Most of the participants that attend a senior university do it for social engagement. Most of the participants are or were in a course to learn a new skill.	Senior Universities can be a good activity if your main goal is social engagement. Senior Universities are not a good place for learning good skills at an academic level. Learning about technology is challenging. Motivation is hard to find, but it can be driven by necessity. Communication is the top motivation for a 55+ adult.

Persona's Data

The previously built empathy maps served as a first step in the creation of personas. Second, the analysis focused on looking for broad patterns in the transcript, interviewees opinions that had significant overlap with other interviewees in most of the critical themes (but not necessarily all). The most noticeable distinguishable characteristic was the participant's relation with ICT and how they incorporated technology daily. The participants were clustered into three comfort levels:

1. is very comfortable and interacts with it regularly,
2. is not very comfortable only interacts with it rarely,
3. is not comfortable, so never interacts with it;

Cluster 1 was coded as the "liberals", the unafraid of technologies, that keep a positive attitude. To represent the liberals, we created Lili (Appendix 1). Cluster 2 was coded as

the “moderates”. This group has their reservations but tries to use technologies when they feel fit to do it. To represent the moderates, we created Mateus, the moderator (Appendix 1). Cluster 3 was coded as the conservatives. This group actively avoids using technology and tries to keep it analogue. To represent the conservatives, we created Cora, the conservator (Appendix 1). This tool was used to build a rich representation of the participants and to nurture the brainstorm phase with empathy.

4.3 Ideate

The Ideate section presents the brainstorming stage where the SCAMPER method is used.

Table 7. SCAMPER Instrument

SCAMPER	Previous solutions	New solutions
Substitute	Fixed script.	Fill in a script adaptable to each narrator.
Combine	Animation. Based on secondary research. Original script.	Live-action and minimal animation. Based on primary and secondary research. Original script with narrator introduction and farewell.
Adapt	Superficial visualisation of similar products.	Benchmarking and comparative study.
Modify	No narrator.	Connecting with the user through the narrator.
Put another use	Inform the user about ICT.	Inspire users to participate as narrators in the following videos.
Eliminate	Subtitles in the video. Music.	Optional subtitles. No music.
Reverse	One screen. Bright colour palette. No narrator. Simplified illustrations. No voice narrating the content.	Split-screen. Sober colour palette. Visible narrator. Realistic illustrations. Voice narrating the content.

4.4 Prototype: “A” version artefacts - outcome of the co-design thinking process

In this stage, we developed two prototypes that will be coded in this study as the “A” versions. For the pre-production phase, we created two scripts and three storyboards based on the previous steps. The scripts corresponded to the “What is a desktop computer?” and “What is a laptop?”, the first two lessons of the project ICTskills4All.

Once completed, we advanced to the casting phase. Because of COVID-19 and to keep the filming set safe for everyone involved, the narrators chosen were both adults 55+ from our close circle.

The production phase lasted a day, with the first hours dedicated to preparing and rehearsing. Both narrators were naturally talented communicators, and the filming stage went by smoothly. The material used was a Nikon d3100 camera supported by a filming tripod and a fireball USB microphone. We also opted to use natural light with reflectors to balance harsh shadows for a more natural look.

After collecting all the material, we used Adobe Suite software to edit, enhance and correct the content.

Script

The previously established script served as a base for the creation of the new script. To be evaluated against each other, both scripts needed to contain the same information. The new script focused on a more empathetic approach, with the narrator revealing bits about oneself. The main differences of the new script are:

1. Narrator's introduction.
2. Narrator's first memory with the technology.
3. Narrator's learning story with the device.
4. Narrator's opinion on “why should a person learn more about technology?”
5. Narrator's opinion on “what advantages and benefits does it bring?”
6. [Original script]
7. Narrator's final recommendations to the audience.
8. Narrator's farewell.

Except for point 6, all the points are freely conducted and only scripted by the narrator. For a more in-depth visualisation of both scripts, consult Appendix 2.

Storyboard

During this stage, we developed the concepts and tested different ideas based on the brainstorming results, user feedback and secondary research. The storyboard's end goal was to reflect the findings and decide on an adequate look for the ICT audio-visual learning content. Based on the rule of thirds, with an occidental reading from left to right, the layout structure’s high contrast is meant to create a visual division between the narrator and the text and imagery, just like a book. The narrator’s white frame seems to overlap the dark background, giving it more importance. The circle frame around the narrator centres the person in the space. The type of font used is Poppins, an easy to read sans-serif font with an adequate size proportional to the screen. The layout and sober colour palette are used consistently during the video, with minimal animation for a more natural look. The illustration style is realistic for a more pragmatic reading of the devices. The end screen puts the narrator on the front and centre of the layout to connect more with the audience.

This project only focuses on the design of the content itself, not on the player, but for a more realistic experience, we decided to use Youtube's video player tools for a more in-context approach since it integrates a well designed and complete set of options. Nowadays, video players offer more controls/tools than ever before that can help the user to personalise their visualisation experience. Some of those tools are:

- Play/Pause button.
- Timeline.
- Skip to the following video.
- Adjust volume.
- Toggle for subtitles or closed captions.
- Adjust screen size.
- Change video quality.
- Adjust video player speed.
- Toggle to enable autoplay functionality.
- Rewind and fast-forward.
- The feedback system of the player is also impressive, allowing users to share easily, comment and rate the content.

The following figures show the last version of the storyboards. Figure 2 shows the final version of the frame styles for the title screen. It can be used for the introduction accompanied with the title and topics without a complementary figure. Figure 3 presents how the figure complements can be used in this layout. Lastly, figure 4 is designed for the end screen, clean background with the user in the centre.

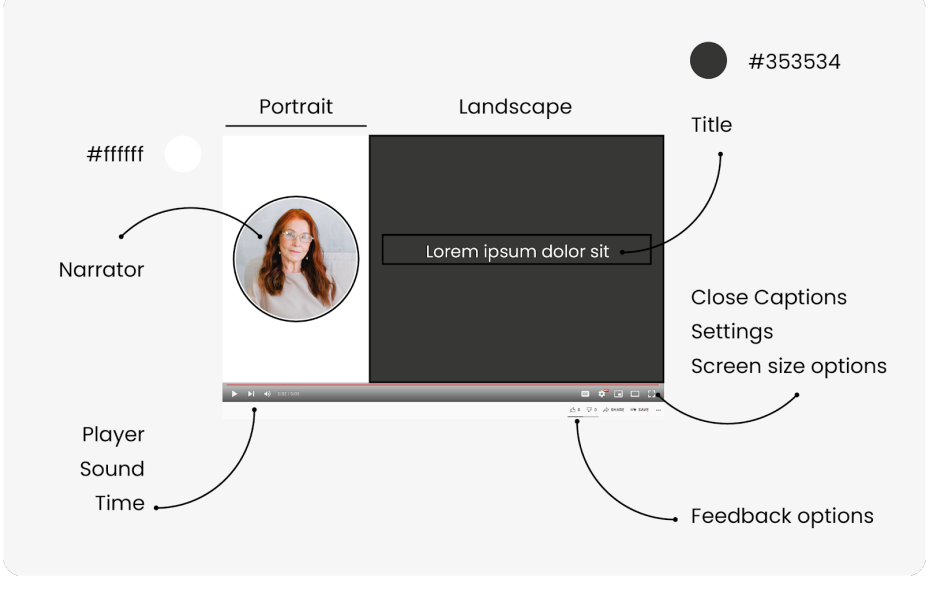

Fig. 2.. Storyboard 1: Title screen for introduction and topics without a figure complement

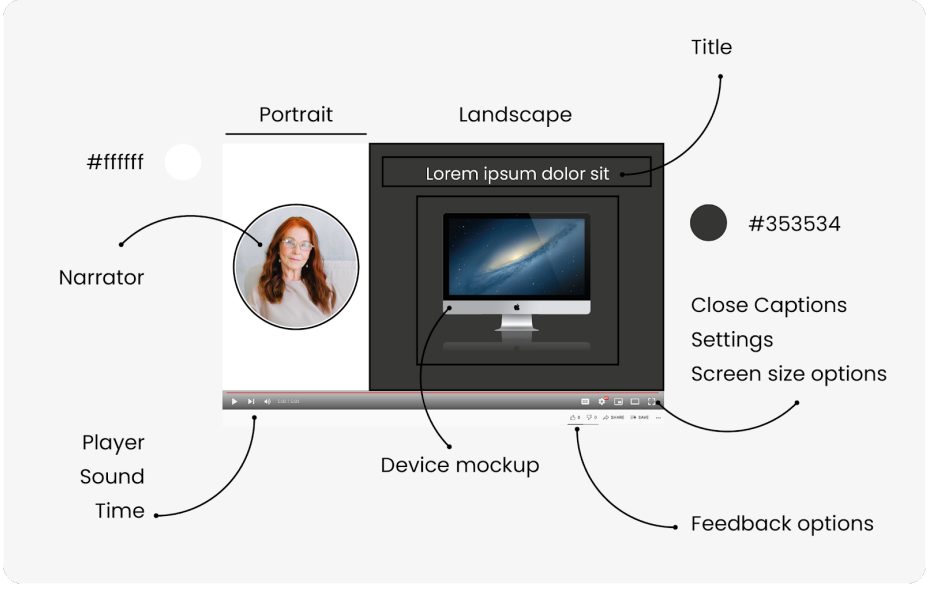

Fig. 3.. Storyboard 2: Title screen for topics with figure complements

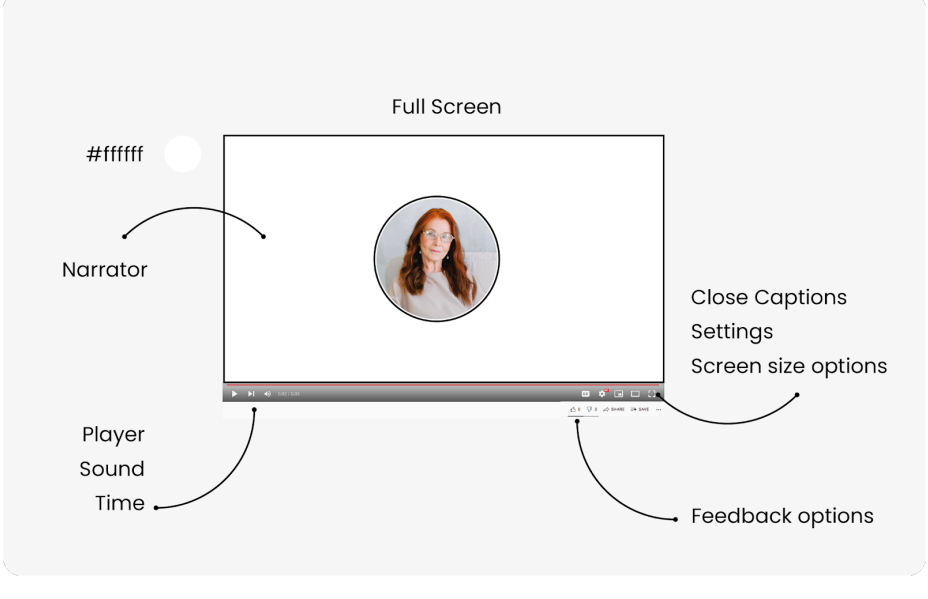

Fig. 4.. Storyboard 2: Title screen for topics with figure complements

The final prototypes were uploaded to Youtube and can be accessed at the following links:

- Prototype A.1:
- https://www.youtube.com/watch?v=S8b97tKknQc
- Prototype A.2:
- https://www.youtube.com/watch?v=pSIkEH73ukE

Figures 5 & 6 show the final prototypes' frames

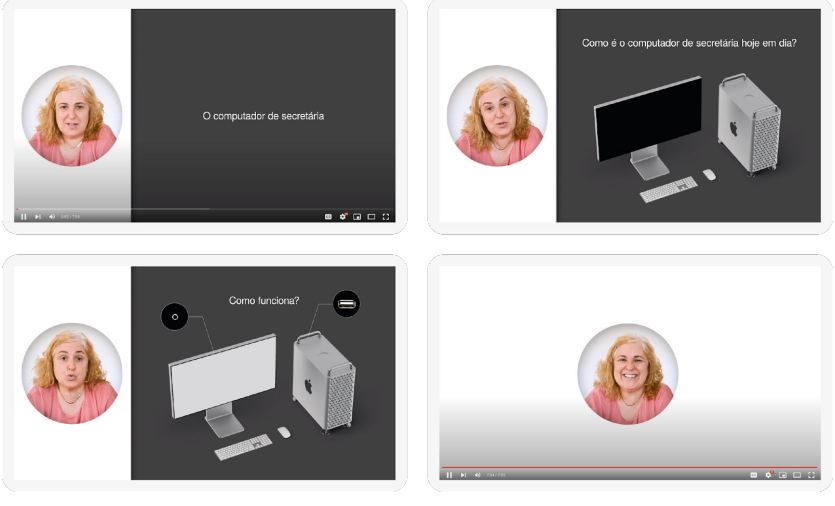

Fig. 5.. Prototype A.1 - video A.1

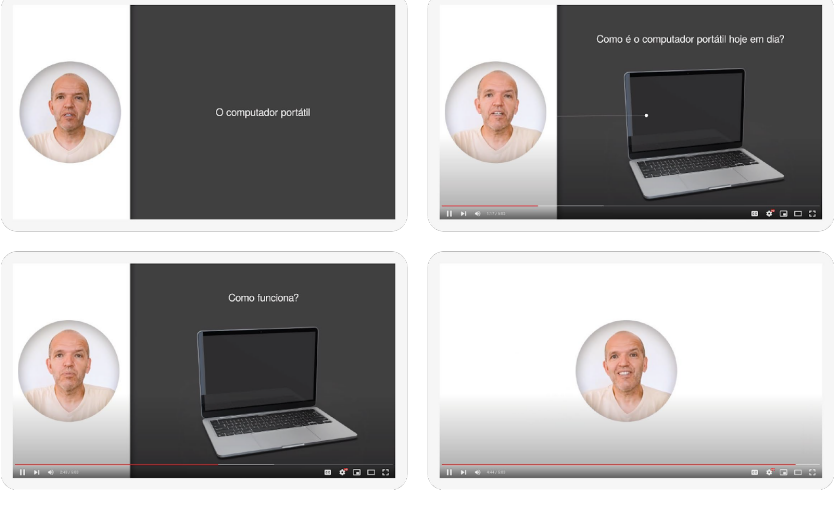

Fig. 6.. Prototype A.2 - video A.2

5 Prototypes "B"

The following prototypes were built with exclusive designer expertise and knowledge. The process started with understanding the end-users through literature research and benchmarking similar products, in this case, active ICT 55+ educational platforms in 2020. The information collected was analysed in a comparative study [37]. The following analysed: the approach available (online versus online and face-to-face), the level of literacy that the content offers, the type of interaction, the characteristics of the audio-visual content, the feedback from its users, and the other formats and presentation networks. As it was not possible in many cases to decipher the age range of the target audience, all ICT educational platforms that were targeted to a senior audience were considered. The data collected influenced the graphic decisions made during the design process.

5.1 Prototype "B": Designing ICT 55+ educational content

Online learning often loses ground compared to on-site learning, considering that social interaction with peers and trainers assumes an essential role in motivating and guiding seniors in the learning process, helping and supporting them in real-time when the user has some difficulty. These are the main shortcomings of online and stand-alone training. Online resources are often partially funded to promote the migration of senior citizens from analogue/presence services to digital ones and thus interact with government institutions and other services. This reduces investment in government services but, at the same time, this can be a problem for adults who value direct contact and interaction to carry out their transactions and solve their problems [33].

Content design emerges as essential to the success of the training offered on these websites and may even determine the sustainability and longevity of online resources. Regarding the analysis, text, illustration, photography, and screenshots prevail as the means of transmitting knowledge and information in ICT teaching platforms, free/open access, with audio-visual content not being a popular choice. However, video, perhaps because it is more expensive in both time and budget, is not as common. When it is, it does not always offer a closed captions option. Half of the platforms do not prioritise digital interaction with the user, limiting themselves to a passive teaching approach, without the possibility of rating, commenting and sharing that is so common on social media and in a classroom environment.

Based on the comparative studies findings, the prototype drafted aimed to create small informative videos that respected the legibility levels that would be comfortable for 55+ older adults. This takes into account: form, colour, size, brightness, contrast, volume and speed.

The building of the "B" prototypes starts with the scripts (Appendix 3). The scripts of both prototypes were created to introduce the basic IT information about the device presented with a simple language. After that, storyboards of the different scenes to be include were drafted, and were considered essential to illustrate. Next phase was dedicated to illustration and gather all the graphics materials contained in the

storyboard. The last step was animation, adding sound and editing the composition to its cleanest form.

The final prototypes were uploaded to Youtube and can be accessed with the following links:

- Prototype B.1:
- https://www.youtube.com/watch?v=dWmku9al0LQ
- Prototype B.2:
- https://www.youtube.com/watch?v=JdTVk9tj0j4&t

Figures 7 & 8 show the final B prototypes' frames

Fig. 5.. Prototype B.1 - video B.1

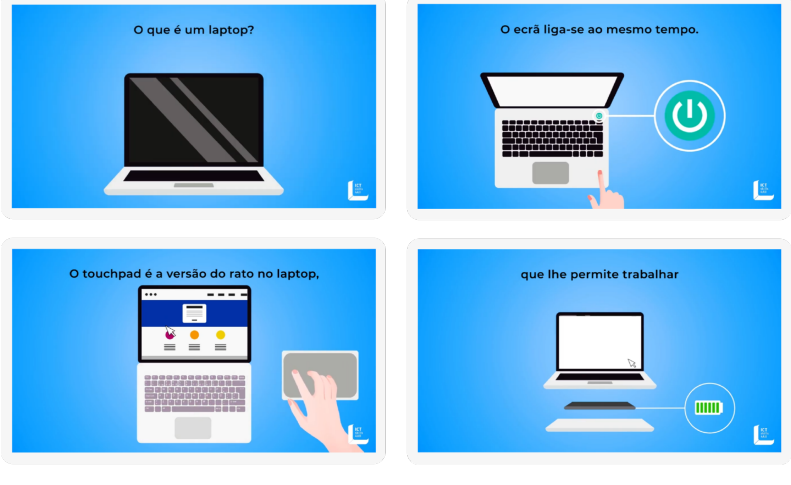

Fig. 6.. Prototype B.2 - video B.2

6 Test: A&B testing of the prototypes

For clarity and to follow reading easier, the A and B audio-visual artifacts will be coded as A.1[co] and A.2[co], and the previous created without the co-creation process as video B.1[n-co] and B.2[n-co].

The tests conducted used the co-designed prototypes detailed in this article as videos A.1[co] and A.2[co] and the previously created videos B.1[n-co] and B.2[n-co]. The participants that constitute the first sample of this study was sent a link to an online questionnaire structured with four sections, to collect participants opinion on each audio-visual content and to determine the preferred audio-visual model (see Appendix 4).

6.1 Survey

The structure that underlies the online questionnaire can be consulted in Appendix 4. As described in chapter 3, the questionnaire presented to the participants is an instrument of evaluation for videos A.1[co], B.1[n-co], A.2[co] and B.2[n-co]. Video A.1[co] and B.1 both correspond to the theme "What is a desktop computer?". Video A.2[co] and B.2[n-co] both correspond to the theme "What is a laptop?".

6.2 Results

The same 25 participants of the study's 1st step were asked to fill in the questionnaire. Of these, 15 participants (6 males and 9 females) completed the task. A table of the sociodemographic characteristics of the participants is presented in Table 8.

Table 8. Sociodemographic Characteristics of Participants engaged in the final A&B test

		Women	Men	Total
N (%)		9 (60.0)	6 (40.0)	15 (100)
Age (mean ± SD)		69.6 ± 6.0	72.6 ± 7.7	70.6 ± 6.7
Marital Status N (%)	Married	7 (46.6)	6 (40.0)	13 (86.6)
	Divorced	2 (13.3)		2 (13.3)
Education N (%)	High School	2 (13.3)	1 (6.6)	3 (20)
	Technical Course	2 (13.3)	3 (20)	5 (33.3)
	Bachelor	3 (20)	1 (44.4)	4 (16.6)
	Masters	2 (13.3)	1 (11.1)	3 (20)
Employment N (%)	Working	2 (13.3)		2 (13.3)
	Retired	7 (46.6)	6 (40.0)	13 (86.6)

6.3 Quantitative Analysis

The UEQ-S (Schrepp, 2016) scale can be split into the pragmatic quality and hedonic quality. Values between -0.8 and 0.8 represent a neutral evaluation of the corresponding scale, values > 0,8 represent a positive evaluation and values < -0,8 represent a negative evaluation. The range of the scales is between -3 (horribly bad) and +3 (extremely good). Due to calculations of means it is extremely unlikely to observe extreme values such as above +2 or below -2 [38].

The questionnaire responses are summarised in Table 9, showing the overall results of each video for comparison purposes.

Table 9. Quantitative analysis: Overall Results of Videos A.1, B.1, A.2, B.2

	Video A.1[co]	Video B.1[n-co]	Video A.2[co]	Video B.2[n-co]
Pragmatic Quality	2.267	1.950	2.050	1.817
Hedonic Quality	0.600	0.950	1.083	0.950
Overall	1.433	1.450	1.567	1.383

Overall the results are all positive and very similar, with video A.2[co] having the highest value of 1.567, second is video B.1[n-co] (1.450), followed by A.1 (1.433) and B.2[n-co] (1.383). The results vary when comparing the videos A.1[co] & A.2[co] with videos B.1[n-co] & B.2[n-co]. In the "what is a desktop computer?" theme, video A.1[co] has a slightly lower value (1.433) than video B.1[n-co] (1.450), but looking into the qualities of the video, video A.1[co] has a superior value in pragmatic qualities. In contrast, video B.1[n-co] has a superior value in hedonic qualities. In the "what is a laptop?" theme, video A.2[co] has a higher value (1.567) than video B.2[n-co] (1.383), with both qualities of the video – pragmatic and hedonic - with superior values.

6.4 Qualitative Analysis

Two open-ended questions followed the visualisation of the videos in each section of the questionnaire: "What you most liked?" and "What you liked least", that were not mandatory so, not all the participants answered them. The codes created are split into two categories: positive and negative feedback.

In the positive feedback, the codes are as follows:

Aesthetics – meaning the visuals, animations, movement.

Clear communication – the communication is presented in a clear and concise format.

Connection – the viewer mentions empathy towards the narrator.

Easy to follow – the feedback mentions how understandable it can be for a person with limited to no digital skills.

Engaging – the feedback encourages and motivates the viewer

Informative – the feedback mentions educational purposes.

Narrator appreciation – the feedback is related to the narrator's interventions.
Theme appreciation – the feedback mentions the importance of the video theme.

In the negative feedback, the codes are as follows:
Basic – too easy.
Distractive – too much clutter.
Inappropriate music – loud or disturbing music.
Limited information – incomplete explanation on the subject.
Missing narrator – missing a human explainer on camera.
Nothing – no negative feedback.
Outdated theme – the theme is no longer relevant.
Repetitive – the information is repeating itself.
Speed (too fast) – not enough pauses to assimilate.
Too informal – concerning the language.

Table 10 shows the frequency of the sample's opinion, with the number of similar opinions/ total number of answers to a specific open-ended question, for each video. According to the respondents, video A.1[co] strengths are "clear communication" (8/15) and "easy to follow" (6/15), and weaknesses are "basic" (2/12) and "limited information" (2/12). Video B.1[n-co] strengths are "aesthetics" (7/14) and "clear communication" (5/14), and weakness are "basic" (3/14) and "missing narrator" (2/14). Video A.2[co] strengths are "clear communication" (10/15) and "theme and narrator appreciation" (3/15), and weaknesses are "limited information" (3/13) and "basic" (2/13). Video B.2[n-co] strengths are "clear communication" (7/13) and "easy to follow" (5/13), and weaknesses are "limited information" (3/13), "inappropriate music" (2/13) and "repetitive" (2/13).

Table 10. Qualitative Analysis: Overall Results of Videos A.1, A.2, B.1, B.2

	Codes	Video A.1[co]	Video B.1[n-co]	Video A.2[co]	Video B.2[n-co]
Positive	Aesthetics	1/15	7/14		2/13
	Clear communication	8/15	5/14	10/15	7/13
	Connection	1/15			
	Easy to follow	6/15	2/14	2/15	5/13
	Engaging	1/15		1/15	
	Informative		1/14		
	Narrator appreciation	4/15		3/15	
	Theme appreciation	1/15		3/15	2/13
Negative	Basic	2/12	3/14	2/13	
	Distractive				1/13
	Inappropriate music		1/14		2/13
	Limited information	2/12	1/14	3/13	4/13
	Missing narrator		2/14		1/13
	Nothing	6/12	6/14	7/13	4/13
	Outdated theme	1/12	1/14		

	Repetitive	1/12		1/13	2/13
	Speed (too fast)		1/14		
	Too informal	1/12			

7 Findings and Discussion

In general, when digital education is not introduced early as a part of the person's work goals, it becomes much harder to incorporate and adapt to ICT and consequently adopt ICT audio-visual learning. Limitations such as insecurities regarding ones' capabilities, lack of accessibility to the devices or Internet and learning without family/ friend's support can prevent adults 55+ from connecting in web-based education. Our sample was mostly constituted of beginners to intermediate level users and no experts, happy to access ICT education at their own pace, but they also mentioned how vital a traditional classroom is to support learning. Additionally, sociodemographic variables such as: gender, age and academic degree did not reveal relevant differences in the users' perceptions.

This study also revealed that all the participants had a smartphone and use it as the primary communication device. They firmly believe that this device is essential because it has multiple functionalities yet it's small enough to be carried to many places. Our participants would like the devices to work for them, make their lives better by helping them to complete and manage daily activities. They do not want technology to interfere with their daily lives, and they do not want to make a big effort to keep up with the constant changes and upgrades in technology. Specific physical or mental barriers were acknowledged, even so, the majority is willing to use technology. Despite the positive results, many are reluctant to use technology to its fullest potential due to fear of being victims of phishing scams, hackers, and data breaches, resulting in loss of money, personal information, as well as causing other potential problems. In addition, they believe that technology can be time-consuming, and they are concerned with being too dependent of technology to do certain things. Participants enjoy activities facilitated by technology such as entertainment, communicating with their loved ones, physical exercising, and keeping up with the daily news.

Educating and helping adults 55+ on digital literacy can make them feel more secure and empowered as they use technology and improve their quality of life. Having said this, some adults still reveal difficulties in accessing good ICT education due to poor opportunities, costs and physical or mental barriers. According to the opinions collected, senior universities have not yet worked on their users' perception that goes from "learning institutions" to "social meeting points". And other more rigorous learning courses are perceived as aimed at professionals who are still active, not retired adults. This can be very discouraging for someone who is searching for a starting point in their digital literacy learning path. Due to these issues it is important to create safe online resources with professional revised content and proper safety measures so 55+ adults can have more options and feel comfortable using technology.

8 Conclusion, Limitations and Future work

At this point of technological progress, adults 55+ should not need to adapt to new technology; technology should already be accessible, flexible, and reliable for people of all ages, including this specific age range of end users. For that to happen it is essential to study design processes of creation and co-creation to produce solutions for more inclusive digital products. As suggested within this study's results, human-centric approaches can be a great way to produce content and a more meaningful experience for the designer and users, even with a small sample.

Improvements can be met for the reported study - the small sample and the unequal distribution of gender, age and level of education among the participants might have biased the results. It would have been preferable to gather more participants and a more even distribution. This was a direct consequence of its context, this study was developed inside the European Project ICTskills4All with an associated partner. For this reason, these results cannot be extrapolated to other contexts.
The respondents were all connected through the association APRE! with common hobbies and social habits, which probably also limited the information gathered and the generalizability of the results.

With this study, we aim to contribute with audio-visual artefacts for the online platform ICTskills4All, co-designed and validated with end-users, able to improve digital literacy skills; and also contribute to the user-centred design field, with a qualitative study based on a design thinking approach. One of the most important lessons learned about participatory design is related to the value of open communication. Even with a small sample, we encourage all the creators to involve the end-users in the design process for more inclusive and accessible products. We are planning, in the near-future, to test our design with end-users, from other socio-economic contexts, to gather feedback before launching it to a bigger audience. We are also planning on using this process to improve and grow the online platform ICTskills4All. For this purpose, we plan to involve other co-creators and introduce a bigger sample in our participatory design (co-creative) process of more audio-visual artifacts.

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Appendices

Appendix 1
https://drive.google.com/file/d/11fL37unPuHMwwIzZiNL8FsTIMX3ga33A/view?usp=sharing

Appendix 2
https://drive.google.com/file/d/1DnP2icNrsythGcfUJzUxeLmfKfnLlXt7/view?usp=sharing

Appendix 3
https://drive.google.com/file/d/1bRkTYzyq2Phz68mL0belsMwN7MEZgNlJ/view?usp=sharing

Appendix 4
https://docs.google.com/forms/d/e/1FAIpQLSdQddmk1dHqCg33tPEeXlhgxrlQPtWoz1Dz3A9JWKAwcYqC7w/viewform