TransInformação

A review of the development of interactive applications for older adults: an Information and Communication Technologies literacy approach

Uma revisão para o desenvolvimento de aplicações interativas para idosos: uma abordagem de alfabetização em Tecnologias de Informação e Comunicação

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Abstract

In the digital context in which society finds itself today, older adults must be allowed to access the use of innovative technologies, and one way to do so is by designing and developing practical, valuable, and easy-to-use applications for them. This article presents the results of a study conducted to characterize software development practices aimed at generating inclusive environments for older adults and proposes a general form of practice. Systematic literature review procedures were followed to select relevant scientific studies that refer to software development practices and processes for older people. Class diagrams were used to describe how, in each study, the authors define the practices they apply to develop applications to generate inclusive environments for older people. Class diagrams describe concepts (classes) integrated into conceptualizing practice and the structural relationships between these classes. Furthermore, the class diagrams allowed a general vision that made it easier to identify the common and differential elements of the vision of the different authors whose studies were analyzed in this research. The general form of practice resulting from this research can make it easier for developers to identify essential elements that should be considered when creating applications for older adults. Ultimately, the software products developed through this orientation have been part of Information and Communication Technologies literacy processes for older adults.

Keywords: Elderly. ICT Literacy. Technology acceptance. Usability.

Resumo

No contexto digital em que a sociedade se encontra hoje, os idosos devem ter acesso à utilização de tecnologias inovadoras, e uma forma de o fazer é conceber e desenvolver aplicações úteis, valiosas e fáceis de utilizar para eles. Este artigo apresenta os resultados de um estudo realizado para caracterizar práticas de desenvolvimento de software destinadas a gerar ambientes inclusivos para idosos e propor uma forma geral de prática. Para selecionar estudos científicos relevantes que se refiram a práticas e processos de desenvolvimento de software para idosos, foram seguidos procedimentos de revisão sistemática da literatura. Foram utilizados diagramas de classes para descrever como, em cada estudo, os autores definem as práticas que aplicam no desenvolvimento de aplicações destinadas a gerar ambientes inclusivos para pessoas idosas. Os diagramas de classes permitem a descrição de conceitos (classes), que são integrados na conceituação da prática e nas relações estruturais entre essas classes. Além disso, os diagramas de classes permitiram uma visão geral que facilitou a identificação dos elementos comuns e diferenciais da visão dos diferentes autores cujos estudos foram analisados nesta pesquisa. A forma geral de prática resultante desta pesquisa pode facilitar aos desenvolvedores a identificação de elementos importantes que devem ser considerados na criação de aplicativos para idosos. No final, os produtos de softwares desenvolvidos através desta orientação fizeram parte dos processos de alfabetização em Information and Communication Technologies para adultos mais velhos.

Palavras-chave: *Idoso. Alfabetização em TIC. Aceitação de tecnologia. Usabilidade.*

Introduction

Technology advances are rapidly present in daily life now more than ever, so such advances can be considered valid, easy to use, and intuitive. Larger screens, more comfortable keyboards, more intuitive interfaces, and simpler processes have helped make technology an essential part of our society, offering solutions to older people's problems without being successful since these people find it hard to learn how to use it. Older adults appreciate technology and recognize its advantages and usefulness. However, when it comes to interacting with a computer, a tablet, or a smartphone, sometimes they find themselves in an environment that is strange to them.

The challenge that the use of technology represents for older adults is broad and involves several areas that involve cognitive, physical, emotional, design, access, and cultural aspects. Addressing these challenges requires an approach where the older adult is welcomed by providing opportunities for adaptation, especially about the design and development of technologies, as well as continuous support, even more so when developing educational resources to facilitate digital literacy in this age group.

Information and Communication Technologies (ICT) literacy for older adults is necessary and very important to help them overcome the challenges of using technology, and in the process improve their daily activities. Even though rapid technological advances have made screens larger, keyboards more comfortable, interfaces more intuitive, and processes simpler, older adults still find it difficult to learn how to use these technologies.

We live in a society with an aging population, in which the number of people over 65 years of age is increasing significantly (United Nations, 2019). In parallel, there is a growing amount of technology deployed for people; with the aging population, it will be increasingly important to properly define requirements when designing systems and applications to meet the needs of older adults (Archundia *et al.*, 2016). It is increasingly common to see older adults with some type of technological device accessing the systems, it is therefore necessary to take advantage of these benefits in communications to help avoid their social isolation.

Older adults today face a social context in which technology is increasingly dominant in several aspects of daily life, sometimes affecting their integration into the new challenges they

encounter in this digital age. Older adults must be allowed to access the use of technologies, and one way to do so is by designing and developing practical and easy applications. This study aims to characterize the practices used in developing software to generate inclusive environments for older adults and define a general form of exercise to introduce them to an ICT literacy process.

This study aims to characterize the practices used in software development to generate inclusive environments for older adults and define a general form of practice to introduce them to an ICT literacy process; to achieve this, the following research question was raised: what practices are used in the development of software that contributes to the social integration of older adults? Additionally, it was crucial to understand and address the various challenges older adults face when interacting with technology. These challenges can be mentioned in six main categories: cognitive and learning challenges, physical challenges, psychological and emotional challenges, design and usability challenges, access and support challenges, and socioeconomic and cultural challenges.

This document has six sections. Section 1 presents the introduction to the study conducted. Section 2 shows an approach to software development practices and inclusive environments for older people. Section 3 describes the methodology used in the development of the study. Section 4 details the results obtained. Section 5 presents the discussion. Finally, section 6 presents the conclusions and future work.

Software Development Practice

The *Object Management Group in the Kernel and Language for Software Engineering Methods* (*Essence*), Version 1.2 standard, defines the practice as a repeatable approach to accomplish a specific purpose. Practice provides a systematic and verifiable way of approaching a particular aspect of a job. The practice has a clear objective expressed in terms of the results that its application allows and provides a guide to help professionals in what must be done to achieve the goal, to ensure that the objective is understood, and to verify that it is completed (Object Management Group, 2018). The Essence Standard, as defined by the Object Management Group, outlines practice as a repeatable approach with a specific purpose. This involves:

• Systematic and Verifiable Approach: Ensuring that each step can be consistently applied, and its effectiveness can be measured. In this case, applications that allow the elderly to learn the basics of establishing communication, for example, or to make checklists for purchases, medications or other activities related to their daily needs.

• Clear Objective: Defining what the practice aims to achieve, making the end goal comprehensible. The practice can get the older adult to make calls and send messages via instant messaging, it can help create recreational spaces through games.

• Guidance for Professionals: Offering a step-by-step guide to ensure that professionals understand the users' needs.

Eclipse Process Framework Composer (EPFC) is a tool for software process management in organizations. EPFC allows processes to be defined from software practices embedded in methods. In EPFC, practice is a documented approach to solving one or several commonly occurring problems. The practice in EPFC is associated with the work products that the practice generates, the tasks that define the development steps of the practice, the guidelines that indicate the practice's application, and the participants' roles (Eclipse Foundation, 2020).

Environment of inclusion of the elderly

An environment is everything that surrounds us, with which we can interact and where and with which we develop life. How it is configured will determine our possibilities of growing in it and adapting our lives (Muntadas, 2014).

Inclusive environments are adaptive, fluid, and evolving contexts that accommodate ICT-enabled spaces, designs, and services that involve an interactive dynamic of people, technologies, and cities with emerging forms (interactions, relationships, urbanization) and attributes (awareness, choice, improvisation) (McKenna, 2019).

Older adults are defined according to several characteristics, including chronological age, social role change, and functional abilities (Kang; Pai; Kim, 2019).

In this order of ideas, when speaking of environments for the inclusion of the elderly, reference is made to the adaptations that give them access to information, allow older adults to interact in different social contexts, and help to improve their quality of life, considering that in some cases their cognitive or physical abilities are diminished.

Information and Communication Technologies literacy

Literacy in Information and Communication Technologies (ICT) involves effectively adopting, adapting, and using digital devices, applications, and services. This includes navigating online platforms and utilizing various software tools, such as word processors, presentation software, and Learning Management Systems (LMS) (Insuasti; Roa; Zapata-Jaramillo, 2023). Strong ICT skills are essential for online learners' success, as courses may require activities like video conferencing, web design, podcasting, or video creation. Developing patience and problem-solving skills to learn new software tools is also integral to ICT literacy (Nedeljko; Bogataj; Kaucic, 2021).

The ICT literacy is increasingly crucial in elder education, equipping older adults with essential skills to navigate the digital world. The ICT literacy enables seniors to stay connected with family and friends through social media, email, and video calls, reducing feelings of isolation and enhancing their social well-being. Moreover, it provides access to a wealth of information and services, including online banking, telehealth, and educational resources, which promote lifelong learning and independence. By fostering ICT literacy, elder education programs help bridge the digital divide, empowering older adults to participate fully in the modern, technology-driven society and improve their overall quality of life.

Methodological Procedures

This study was developed to contribute to the characterization of software development practices aimed at generating inclusion environments for older adults and to be able to define a general form of exercise. For the characterization analysis, the Systematic Literature Review process proposed by Kitchenham and Charters (Kitchenham; Charters, 2007), in which specialized digital databases were used as sources of relevant studies: ACM Digital Library, IEEE Xplore Digital Library, ScienceDirect, Web of Science, and Scopus, since they compile a large bibliographic production of scientific-technical content around computing; also, studies reported by experts were analyzed.

The following research question was defined to guide the search for primary studies: what practices are used in the development of software that contributes to the social integration of older adults?

Considering the research question, the main terms, their synonyms, and related terms were identified, from which the following search strings were defined to obtain primary studies in specialized digital repositories:

String 1: (application OR software OR tool) AND (elderly OR "older adults") AND ("social isolation" OR "social integration" OR "social interaction")

String 2: (Methodology OR Technique OR Tool OR framework) AND (application OR software) AND (elderly OR "older adults") AND ("social isolation" OR "social integration" OR "social interaction")

The results obtained using the search strings in the digital databases are shown in Table 1.

For the selection of relevant studies, that is, those that allow us to answer the research question posed, the following inclusion and exclusion criteria were defined:

1) Inclusion
• Studies that refer to software development practices aimed at the elderly.
• Studies that refer to the software development process for the elderly.

2) Exclusion
• Studies that refer only to software components.
• Studies that are intended for a population other than older adults.
• Studies that are outside the 2016–2022 time range.

In the selection process, duplicate studies were first eliminated. Then, the inclusion and exclusion criteria were applied, considering the title, abstract, and keywords. Finally, complete reading and evaluation were conducted to ensure the quality of the items found. Table 1 shows the number of selected studies.

Table 1 – Search results and Selected studies.

Digital study sources	Number of documents recovered			Selected publications		
	String 1	String 2	Total	String 1	String 2	Total
ACM Digital Library	17	8	25	0	0	0
IEEE Xplore Digital Library	4	10	14	1	0	1
Web of Science	16	21	37	1	1	2
Scopus	17	12	29	0	1	1
Science Direct	15	1	16	0	1	1
Total Sources of Digital Studies	69	52	121	2	3	5
Reported by experts		2	2		2	2
Grand Total			123			7

Source: Elaborated by authors (2023).

The selected studies underwent a process of analysis, using class diagrams to describe how, in each one, the authors define the practices they use to develop applications aimed at generating inclusive environments for the elderly.

For the characterization of software development practices aimed at generating inclusion environments for the elderly, those relevant studies were subjected to an analysis process in which the process used to develop the application is named or described, for which they were used – Class diagrams. Class diagrams illustrate the concepts (classes) integrated into conceptualizing the practice and the structural relationships between these classes. In addition, the class diagrams allow a general view in which it is easy to identify the different authors' common and differential elements of the vision.

Results

Information extraction

The relevant studies that underwent the analysis process and the corresponding class diagram are presented below. In these class diagrams, the class that represents the Practice is painted yellow to indicate that it is the main object of study of this research. In addition, the types that describe the characteristics expected in at least two studies that are part of the research are painted blue. Those classes that represent the specific characteristics of a study are painted white.

In Gutierrez *et al.* (2017), the author's experience designing and implementing various versions of the Social Connector system, a computer-supported family communication mediator, is reported as a case study that helps identify critical factors that facilitate family communication – the adoption of intelligent system environments that foster intergenerational family communication at home. The particularity of the study is to bring together widely available mass-market technology, such as commercial tablet PCs and TV screens, coupled with innovative software, as a way to drive system adoption through affordable hardware, and also to that critical design factors identified in the study can be used to inform the design and modeling of intelligent system environments that help older adults address various aspects of their aging process, such as health monitoring, personal security, social commitment, support for daily activities – and promoting well-being. The practices used in this study are design and implementation, case studies, and critical design factors. Figure 1 shows the class diagram that was obtained when performing the analysis.
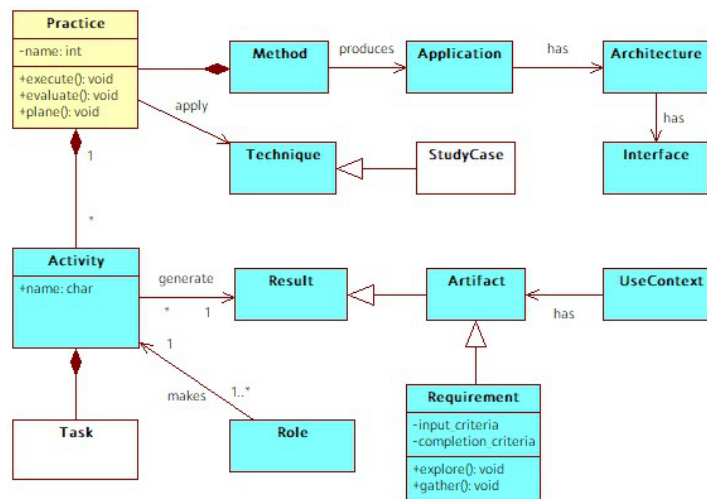

Figure 1 – Extraction of information from the proposal (Gutierrez *et al.*, 2017).
Source: Elaborated by authors (2023).

The same procedure was followed for the construction of the class diagrams of the following six studies:

In Shore *et al.* (2018), the authors contribute to the user-centered design of exoskeletons and prospective approaches to studying older adults' technological acceptance of such devices. In this study, the evolution of the Technology Acceptance Model (TAM) is made in relation to the applications of gerontechnology. The importance of Assistive Technology (AT) models in assessing

the suitability of devices for a person with a disability is discussed. A clear result of the research is the need for empirical research on older adults' use and perceptions of exoskeleton technologies to broaden their understanding of the theoretical and design factors affecting their adoption. The methodology used is User-Centered Design (UCD).

In Minge and Cymek (2020), the attractiveness of various gamification features embedded in an ICT learning software prototype is investigated and compared with a non-gamified version. The results indicate that the gamified ICT learning software appeals to older people in general but that the acceptance of different gamification features is quite diverse. They did not find a clear superiority of adding gamification to software. After interacting with both software versions, seniors either preferred the non-gamified or gamified versions or could not decide. Seniors who chose the gamified version particularly liked the continuous positive feedback and receiving rewards for each task they accomplished. In contrast, the remaining seniors did not enjoy the intensive support through these two features and decided not to use the gamified version. However, they wanted many of the other features of the game. Their results underscore the need for a user-centric design approach when developing game-inspired apps.

The project called "*Photo Alive*" is presented in the study of Syeda and Kwon (2017); it is a proposal for a system and a smartphone application based on a camera to capture photos and send them to a TV or through Social Network Services (SNS). "*Photo Alive*" has a picture gallery where you can display various photos in various patterns and a photo tagging service where you add and listen to audio messages. This app effortlessly bridges the intergenerational gap between older and younger generations by providing a friendly platform for older people using simple, intelligent interfaces and techniques such as remote control, touch panel, and voice. After the development stage, the system was evaluated using techniques that are easily accessible to the elderly by providing user-friendly and intelligent interfaces for the elderly without complications. This application was made using the development method of prototypes and evaluation by Stakeholders.

In Archundia *et al.* (2016), the authors present a work whose purpose is focused on the design and development of a mobile application for devices with the Android system to serve as a personal navigation tool to share the location of users quickly and easily of the elderly, seeking to provide security and facilitate greater inclusion of the use of technology to this population, on the other hand, the design allows the configuration of mobile-accessible interfaces for older adults with hearing and visual disabilities. The Extreme Programming methodology, Universal Design, and the integrated technologies of Webservices, PHP, MYSQL, Java, and Apache were used for the mobile application development. Figure 4 shows the class diagram that was obtained after performing the analysis.

In García-Sánchez (2017), the development of a distributed application that allows people over 60 to contact each other to find company and friendly relationships is presented. In its development, an iterative and incremental software process based on the spiral software process was followed, with an object-oriented analysis and design approach and incorporating good security practices in the software development life cycle (S-SDLC). This way, these technologies' use for social purposes was explored.

In Bravo-Torres *et al.* (2017), the authors present the architecture of the intelligent assistance platform for elderly care (SAFER). The platform's objective is to provide an integrated set of intelligent services that improve the quality of life and social integration of the elderly. The architecture proposed in the study uses technological advances in services and information security

to fulfill its objective (to promote social interaction among the elderly). In addition, a first application for the platform is presented, which consists of an application that recommends events preferred by the elderly, which can be attended by creating sporadic groups with people with similar tastes.

Information synthesis

Taking the class diagrams as input and considering that the objective of the information synthesis is to define a general form of practice, all the classes identified in the relevant studies are initially listed. The result of this task is shown in Table 2.

Subsequently, the classes repeated in at least two studies are identified. Finally, based on the identified classes, an exhaustive analysis is made of those classes that are not repeated and

Table 2 – Classes that were identified in the relevant studies.

Classes	Relevant studies						
	Gutierrez *et al.* (2017)	Shore *et al.* (2018)	Syeda and Kwon (2017)	Archundia *et al.* (2016)	Minge and Cymek (2020)	García-Sánchez (2017)	Bravo *et al.* (2017)
Practice	✓	✓	✓	✓	✓	✓	
Activity	✓	✓	✓	✓	✓	✓	
Administrative				✓			
Acquisition Knowledge							✓
Algorithm							✓
Analysis		✓					
Analysis Risk						✓	
Analyst					✓		
Application	✓	✓	✓	✓	✓	✓	
Machine Learning							✓
Architecture	✓		✓	✓			✓
Artifact	✓	✓	✓		✓	✓	
BaseKnowledge					✓		✓
Layers							✓
Case Study	✓						
Context Use	✓	✓					
Development		✓	✓		✓	✓	
Design					✓	✓	
Simple Design				✓			
Equipment				✓			
Specification						✓	
Assessment		✓	✓				
Evaluation Customer						✓	
Phase				✓		✓	
Functionality				✓			✓
Gamification					✓		
Information		✓					
Engineering						✓	
Interface	✓		✓	✓			✓
Method	✓	✓	✓	✓	✓	✓	
Mining Data							✓
Modeling			✓				
Operational				✓			
Planning						✓	
Prediction							✓
Prototype			✓		✓	✓	
Recommendation							✓

Source: Elaborated by authors (2023).

are essential to define the final general form of the practice. In addition, classes pertinent to the particularity of studies and not to the definition of the last available form of the course are excluded. The result of this task is shown in Table 3.

Table 3 – Classes to define the final general form of the practice.

Classes	Relevant studies						
	Gutierrez *et al.* (2017)	Shore *et al.* (2018)	Syeda and Kwon (2017)	Archundia *et al.* (2016)	Minge and Cymek (2020)	García-Sánchez (2017)	Bravo *et al.* (2017)
Practice	✓	✓	✓	✓	✓	✓	✓
Activity	✓	✓	✓	✓	✓	✓	
Application	✓	✓	✓	✓	✓	✓	✓
Architecture	✓		✓	✓			✓
Phase				✓		✓	
Functionality				✓			✓
Interface	✓		✓	✓			✓
Method	✓	✓	✓	✓	✓	✓	✓
Result	✓	✓	✓		✓	✓	
Role	✓	✓	✓	✓			
Technique	✓				✓		✓
Equipment				✓			
Task	✓						

Source: Elaborated by authors (2023).

The characterization of the software development practice aimed at generating inclusive environments for older adults is conducted based on the results obtained in the information synthesis. Specifically, the classes listed in Table 3 are used to build the class diagram that describes the final general form of the practice, as shown in Figure 2. In this diagram, the *Practica* class is painted yellow to highlight it. As the main object of study of this research, the types that represent the characteristics that are common in at least two studies that are part of the research are painted in blue. In addition, the types that describe the necessary factors, even if used less frequently (*Equipment* and *Task*), are painted white.
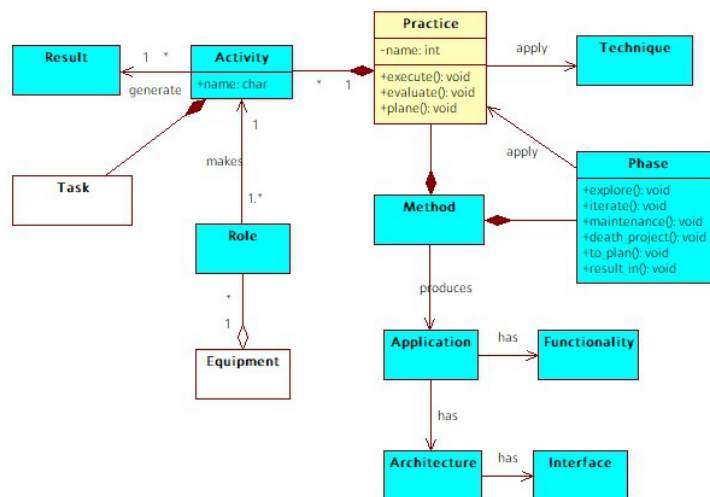

Figure 2 – General form of practice.
Source: Elaborated by authors (2023).

Validation

To verify if the elements that characterize and constitute the general form of practice are sufficient to define existing practices for the development of software aimed at generating inclusion environments for the elderly, studies as Kunnappilly *et al.* (2017) and Ordoñez *et al.* (2017) were identified as practices for developing software to generate inclusive environments for the elderly.

Next, using the elements identified as characteristics of the practices recorded in Table 3, the practices presented by the studies that serve as validation experience of the characterization of practices for developing software aimed at generating inclusion environments for the elderly are defined. These definitions are presented as class diagrams. The class that represents the Practice is painted yellow to indicate that it is the main object of study, and the lessons that represent the common characteristics in practice are painted blue. At least two studies are part of the research, and the classes represent the characteristics considered necessary in white, although they are used less frequently.

At Kunnappilly *et al.* (2017), a novel architectural solution is proposed that integrates the necessary functions of an Ambient Assisted Living (AAL) system, which can be seen as a fully integrated solution with selected functionalities based on the user's choices. The proposed architecture is designed considering the pros and cons of the existing AALs in the literature. The class diagram that describes the practice obtained from the study was made using the elements that characterize the patterns.

In Ordoñez *et al.* (2017), an application is presented to promote social interaction among the elderly. This application is part of the SAFER platform and is focused on meeting the needs of these people. The application stores the profiles of the elderly with the types of events of their preference in a database. A search is done on the web of the events that take place in the city; then, a comparison is made based on the content, and if the characteristics of this event coincide with those preferred by the older adult, the event is recommended the person who indicates place, date, and time. In addition, the system recommends forming a sporadic social group of older adults with similar preferences with whom the older person can interact.

The definition of the practice presented in Ordoñez *et al.* (2017), which is indicated in Figure 3, shows the elements that characterize the practices. These elements are sufficient to describe the practice proposed by the study's authors.
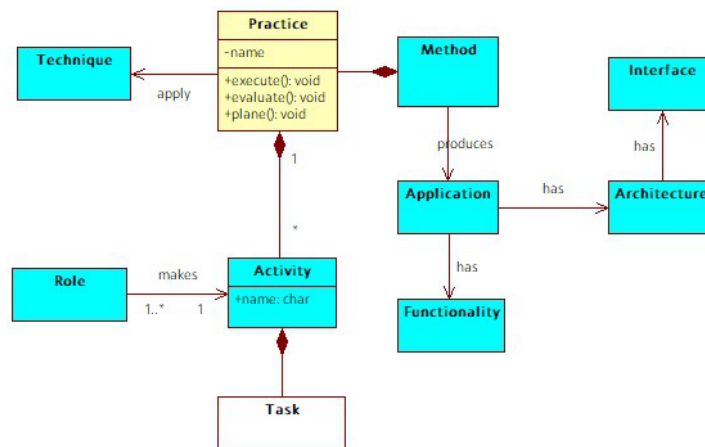

Figure 3 – Class diagram of the study (Ordoñez et al., 2017).
Source: Elaborated by authors (2023).

Once the validation has been conducted, it can be deduced that the characterization of practices identified in this research is sufficient to define existing practices used for developing software to generate inclusive environments for the elderly. Existing practices can be described with the features that characterized the practice and were identified in the Systematic Literature Review. New practices can be built to develop software to generate inclusive environments for older adults. The elements that characterize the practice allow describing practices that facilitate the developer's application in authentic contexts.

Discussion

The general form of practice obtained from this research allows defining practices for developing software to generate inclusive environments for the elderly. This conclusion follows from applying this general form of practice to existing practices. It is appreciated that the elements that make up the general form of practice are necessary and sufficient to describe practices. All the elements of the practices analyzed have their corresponding element in the general form of practice, which guarantees the completeness of representation by omitting those elements that are not essential. In addition, the general form of practice applied to existing practices allows for unifying the terms used to describe the practice.

Proposing specific criteria for designing and developing software for older adults contributes to improving this demographic group's ICT literacy. By focusing on usability and accessibility, the proposed guidelines address vital challenges that older adults face when interacting with digital technologies. Software developed by these guidelines is more likely to be user-friendly and accessible, reducing the digital divide and facilitating the inclusion of older adults in the digital world. This improves their interaction with technology and supports their social inclusion and continuous personal development. Furthermore, it provides essential guidance for developers and designers aiming to create inclusive technology solutions, promoting a shift towards more age-friendly digital environments. The implications of this research offer a pathway for helping older adults remain engaged and active participants in our increasingly digital society.

By offering a structured and comprehensive framework for designing and developing software tailored to the needs of older adults, our solution stands out compared to previous studies. Traditional approaches often overlooked the unique requirements of this demographic, leading to software that was either too complex or inaccessible (Mitzner *et al.*, 2016). In contrast, our research emphasizes the importance of inclusivity from the outset, ensuring that every element of the design process considers the capabilities and limitations of older users. This enhances the user experience and promotes a sense of independence and confidence among elderly individuals as they navigate digital platforms.

Moreover, our practice's emphasis on usability and accessibility addresses specific pain points identified in earlier research. Previous studies have often highlighted older adults' challenges, such as difficulty understanding complex interfaces or navigating through non-intuitive designs (Nedeljko; Bogataj; Kaucic, 2021). By integrating feedback and lessons from these studies, our solution provides straightforward, actionable guidelines that directly tackle these issues. This leads to the development of more intuitive software that reduces cognitive load and minimizes frustration for older users.

Additionally, our approach includes a thorough validation process to ensure the practices are theoretically sound and practical. Previous research sometimes fell short in terms of real-world applicability, with solutions that worked well in controlled environments but failed to meet the needs

of actual users (Mitzner *et al.*, 2016). By rigorously evaluating our practices in diverse real-world settings, we ensure that our proposed solutions are robust, adaptable, and hugely beneficial for the intended user group.

Furthermore, our solution's focus on unifying terminology and standardizing practices offers a significant advantage over past studies. Consistency in terminology and design practices across different projects and teams leads to more cohesive and reliable software development processes. This standardization helps reduce misunderstandings and miscommunications, common barriers in collaborative efforts (Jones, 2009). As a result, developers and designers can work more efficiently, producing higher-quality software in less time.

Finally, the holistic nature of our approach, which encompasses technical, cognitive, and social aspects, sets it apart from previous research. By considering the broader context in which older adults interact with technology, we address the immediate usability issues and the long-term impact on their digital engagement and social inclusion (Morris; Goodman; Brading, 2007). This comprehensive perspective ensures that our solutions are sustainable and can evolve with the changing needs of the elderly population, paving the way for a more inclusive digital future.

In summary, our solution offers a more inclusive, user-friendly, and standardized approach to software development for older adults compared to previous studies. By addressing specific usability challenges, validating practices in real-world settings, and promoting consistency and comprehensiveness, we provide a robust framework that significantly enhances the digital literacy and inclusion of the elderly.

Conclusions and future work

Investment in software design that meets the specific needs of older adults not only improves their quality of digital life but also strengthens their active participation in today's digital society, this is visible in literacy in ICT for older adults which brings several advantages, since it has become an essential element for their active social participation and general well-being. As more seniors join the Internet, software developers must adopt design practices tailored to this demographic.

Effective software design for older adults should emphasize accessibility, usability, and intuitive navigation. This is essential to address possible deteriorations in vision, hearing, and motor skills that they may experience with age. By doing so, developers significantly improve the user experience of older adults, encouraging their independence and connectivity. In addition, older adults must be trained in the use of ICT so that they can access essential services, maintain social connections, and continue learning throughout their lives. This interdependence between user-centered design and ICT literacy contributes not only to individual well-being but also to the digital inclusion of this segment of the population.

The general form of practice resulting from this research can make it easier for developers to define rules to build applications that promote the social inclusion of older adults. With this general form, new and existing rules can be determined using the elements proposed by relevant studies. Thus, other investigations with this type of practice as an object of study can use this characterization as an analysis criterion.

The characterization of software development practices aimed at generating inclusion environments for the elderly allowed the definition of a general form of the methods that developers use, which will be incorporated into the description of a specific process model for the design of applications based on collaborative, playful and ubiquitous environments, to promote the social integration of older adults, and reduce the problems that appear when they use technology.

The general form of practice was validated through its application in three reference studies. From this experience, it can be deduced that the elements of characterization of practices that are identified in this research are sufficient to define existing practices that are used for the development of software aimed at generating environments of inclusion for the elderly.

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