UIAAC: A Method for Designing of Graphical User Interface for Augmentative and Alternative Communication

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Abstract: The world's population is aging, which is reflected in the increased proportion of older adults, both in developed and developing countries. In 2019, 1 in 11 people exceeded 65 years old; and it is projected that by 2050, this proportion will be 1 in 6 people. Among the most common problems older adults face are those linked to physical, auditory, and visual impairment and, affect, the way they communicate and interact with others. While the usual way of communication is through speech, 1.3% do not depend on verbal language, and as a result, their communication needs are not met. Therefore, it is necessary to search for other modes of communication (apart from speech), which are used to express thoughts, needs, desires, and ideas. An option is Augmentative and Alternative Communication (AAC), which presents methods and technology to help people develop or regain communication ability. Thus, this document presents a method called UIAAC, which aims to facilitate the design of graphical user interfaces for AAC systems oriented to older adults and incorporate pictograms as a means of communication. The presented method is aligned with usability standards and considerations of experts in AAC, gerontology, software quality engineers, and user-centered design. To assess the feasibility of the method, the design of a prototype interface and a case study that assesses the perception of the prototype's use is presented. The evaluation was developed from the point of view of the psychological area and the end-user (older adult).

SCIENCE AND TECHNOLOGY PUBLICATIONS

1 INTRODUCTION

Currently, the proportion of older adults has increased considerably in the world (Office Statistics, 2015). This age group faces many problems related to their age; the most common are physical, hearing, and visual impairment that significantly affects how they communicate and interact with other people (World Health Organization, 2011). For this reason, researchers are motivated to seek alternative technologies or methods to help people improve or regain the ability to communicate. Thus Augmentative and Alternative Communication (AAC) appears and becomes indispensable (Beukelman & Light, 2020). It can be achieved through AAC systems, which are applications that incorporate some technological means as information output and provide innovative solutions for a wide range of users with speech disabilities (Waller, 2019). One of the means of interaction that the AAC incorporates is the use of pictograms, which are figurative drawings, used to transmit information directly, indicate an object, verb, place, or express an idea when users speak with limited language skills or have visual problems (Tijus et al., 2007). The receiver can interpret pictograms in a more precise and agile way than words. Therefore they serve as an instant reminder, such as a danger sign or a specific message (Portugal et al., 2013).

Most AAC systems incorporate a graphical interface for user interaction. This interface must consider the criteria of usability and accessibility to provide the best possible user experience; if an interface is adequate, the user will be able to slide and

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use the system without making much effort. On the contrary, the user can easily become confused, resulting in low interaction efficiency (Pressman, 2010).

Consequently, the design and construction of interfaces are an essential part of the software development process, and in most cases, they account for about half of the code developed in a system (Labib et al., 2009). Several primary studies address the creation of AAC systems and graphical interface design oriented to end-users in different domains. In this sense, Keskinen et al. (2012) present a communication system called SymbolChat, which considers the needs of users from different perspectives by customizing the elements of the graphical interface displayed to the user. Although this system presents a good alternative for communication, it does not focus on older adults and does not consider accessibility aspects aimed at this particular group. Miguel et al. (2018) present a project that focuses on designing graphical interfaces aimed at older adults called Ni nanna, which consists of a web application for touch devices that provides advice from older adults with knowledge in artistic activities to users who require some advice. Its interfaces are designed according to the User-Centered Design (UCD) methodology that proposes a design based on understanding, study, design, construction, and evaluation. The present research does not specify details of the process followed in each subphases. These proposals address the design of interfaces and forms of interaction; however, the users' skills to whom they are directed are not directed, which represents difficulties at the time of their use (Al Mahmud & Martens, 2016). In general, this leads to not effectively measuring the usability of the different components presented to the user (Saturno et al., 2015).

Consequently, it is necessary to have a method that guides user interface design with AAC communication modalities, to improve the interaction between older adults and high-tech AAC systems through pictograms. This document presents a method to design graphical interfaces for the AAC using pictograms. It has been named UIAAC (User Interface Alternative and Augmentative Communication). This method includes all aspects related to accessibility in order to design effective interfaces for older adults. Therefore, the main contributions of this research are: i) An initial version of the IUAAC method, its phases, guidelines, and artifacts involved, ii) the design of a functional prototype of an interface for an AAC system, designed taking into account each step of IUAAC, iii) a case study that shows the use of the prototype aimed at improving cognitive abilities and that has been used by two older adults, their perceptions and comments on the experience of using the prototype, and iv) the psychologist's point of view on the designed prototype.

Finally, this article has the following structure: Section 2 presents the related works; Section 3 presents the IUAAC method and its phases; Section 4 shows the feasibility of the method by designing an interface for an AAC system; section 5 presents a case study in which older adults and health experts participate; and finally, Section 6 presents the conclusions and future work.

2 RELATED WORK

This section presents studies that present methods or considerations for designing and implementing interfaces for AAC systems. The objective is to verify the existence of methods to design or build interfaces for AAC systems that use pictograms and are aimed at older adults. Miguel et al. (2018) present an interface to facilitate the interaction of the older persons with people who require some advice, for which they use the UCD methodology. Griffith et al. (2014) present a study in which they examine how an AAC device's interface design influences people's behaviors with aphasia during a narrative counting task. Likewise, Walsh (2010) presents the design and development of an intuitive interface for an AAC system that is based on commercial quality statements.

On the other hand, Pavlov et al., (2018) present a study that describes the approach and decisions that should be considered to build accessible interfaces for users with verbal and written communication disorders. Furthermore, it describes the TESI system's interface design, whose objective is to improve oral expression skills. Finally, Light et al. (2019) present research on the impact of the AAC variables in children and adults' visual attention with acquired diseases; it also presents considerations on these variables' implications for effective design of the interfaces for visual scene displays.

Moreover, older adults are immersed in a society that experiences a constant advance in information and communication technologies (ICT) (Agudo Prado et al., 2013). It has been determined that ICT support in the AAC has been recognized as a key factor to improve the inclusion of people with complex communication needs in daily life. It is supported by Matijević et al. (2014), who present a method of initial automatic adaptation of user

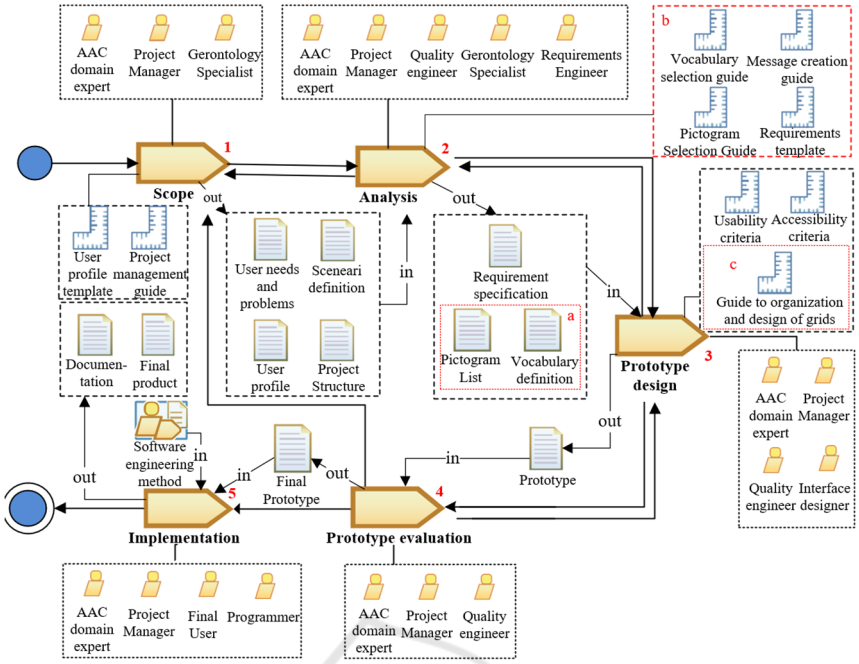

Figure 1: Main method for design of graphical user interface to AAC systems (UIAAC).

interfaces, which is then distributed among AAC applications through a specialized platform. This solution's goal is to produce components without the need for actual user testing. According to the solutions presented, it is possible to conclude that there is no method for designing interfaces for AAC systems where pictograms are used to communicate aimed at the older persons. This conclusion is supported by a systematic review that we have carried out previously and which is expected to be published soon; It has the objective of knowing which are the existing methods, tools and technological solutions used in the design of AAC interfaces and creation of AAC solutions in general.

3 THE UIAAC METHOD

Therefore, for the design of an interface for an AAC system, aimed at improving the communication skills of an older adult, a design method has been created, which considers accessibility characteristics and also integrates several professionals from different areas of knowledge (e.g., psychologists, software engineers, project specialists).

3.1 UIAAC

The first activities concerning to UCD are alinged with the principles proposed by Gould & Lewis (1983); here, some activities oriented to interface design have emerged, for example, those proposed by Wallach & Scholz (2012).

The UIAAC method contains the following phases: i) scope, ii) analysis, iii) prototype design, iv) prototype evaluation, and v) implementation. These phases are presented in Figure 1, and each of them is explained below:

3.1.1 Scope

This activity is shown in Figure 1 (1), where the AAC domain expert, the project manager, and the gerontology specialist intervene. Understanding the domain and shared knowledge among the participants makes it possible to obtain the following artifacts: user needs and problems, scene definition, user profile, and project structure. They serve as the basis for the analysis phase. In these documents, the scenario where the user will interact with the system will be detailed. A user profile will also be obtained with different characteristics to understand better the problems and needs that the user presents and, finally, a project structure to guide each phase of the proposed method.

3.1.2 Analysis

This activity is shown in Figure 1 (2). It is based on the user needs and problems, scene definition, user profile, and project structure documents. The domain expert,

the requirements engineer, the quality engineer, the project manager, and the gerontology specialist perform the requirements elicitation phase, which delivers the requirements specification document-oriented to the interface design as an artifact. Additionally, the vocabulary selection, message creation, and pictogram selection guides can be used by the gerontology specialist and domain expert.

3.1.3 Prototype Design

This activity is shown in Figure 1 (3); the quality engineer, the project manager, and the domain expert carry out a conceptual design based on the documents generated in the analysis phase. Additionally, the interface designer and the quality engineer carry out the design and prototyping using a prototyping tool. Design is guided by usability and accessibility criteria guidelines; also by an organization and design guide of grids suitable to adapting pictograms on the interface.

3.1.4 Prototype Evaluation

This activity is shown in Figure 1 (4). Within it is the prototype verification and validation tasks, which the project manager and quality engineer execute. In this phase, it is important to ensure the prototype's quality and is considered purely iterative in conjunction with the prototype design phase. Once a quality product has been achieved and meets the proposed requirements, it is considered that the objective of the method has been achieved.

3.1.5 Implementation

This activity is shown in Figure 1 (5), from the designed prototype, and through a software engineering process, a functional interface is implemented to adapt it in the AAC system.

3.2 Artifacts in the UIAAC Method

3.2.1 Document of User Needs and Problems

This document specifies the needs and problems that the user faces. Each need is analyzed to understand the situation. Here the user is located, and from this, they can have a global idea about the type of system that the user needs.

3.2.2 User Profile

The user profile is defined based on knowing in detail the characteristics of the person to whom the interface is aimed. Among them is information about the motivations and aspirations of the graphical interface and the AAC system. It is also considered essential to know the degree of familiarity that the user has with the different technologies.

3.2.3 Scenario Definition

Having the setting defined, it is essential to frame the product's use or its need for use (Hassan, 2015). Documenting the place where the actions will occur is important because it allows the project to be tailored to a specific situation; in addition to that, the scenario represents the real situation where the user will interact with the AAC system to meet an objective.

3.2.4 Project Structure

The project structure is a document that defines the activities and how they will be grouped and coordinated to guide the design process of the AAC interface aimed at older adults. It also defines each phase's workgroups, roles, and activities to optimize the resources and time to invest in each phase. The objectives and limitations of the project are also established here. Finally, the work structure is designed based on the definition of the scope and should be guided by the domain expert's observations in the AAC and built by the project manager.

3.2.5 Requirements Specification

As a product of the requirements elicitation, a requirements specification document is obtained. This should be clear, unambiguous, easy to understand, complete, and consistent. This document is organized by Somerville's structure and includes the functional and non-functional requirements of the interface.

3.2.6 Definition of Vocabulary and Messages

This document contains the domain vocabulary characteristics chosen to adapt it in the interface. It can also contain a list of common messages that help to synthesize an idea to increase the communication skills of the older persons in particular everyday situations.

3.2.7 List of Pictograms

Once the domain, vocabulary list, and messages of the AAC system have been defined and based on selection criteria of pictograms aimed at the older persons, the most suitable pictograms can be chosen

to be integrated into the interface. It is essential to define and validate that pictograms increase the user's ability to communicate without using verbal language.

3.2.8 Conceptual Design

It is a document that refers to the decisions regarding the graphic interface design and the interface model. Represents a plan or skeleton that allows communication from the beginning, how the interface will interact. Conceptual design is the tool used to communicate the intention of our design.

3.2.9 Initial Prototype

It is a visual representation of the conceptual design and helps verify that the interface is designed according to the expected requirements. It can be designed in different tools, and its purpose is to offer a tangible product that can be evaluated and accepted for later implementation. It usually is functional, but its features are limited.

3.2.10 Version List and Final Prototype

This document contains all the versions created of the prototype and includes the changes and improvements with respect to its predecessors are. It is the final approved and validated version of the prototype, with which the AAC system will be implemented.

3.3 Guidelines in the UIAAC Method

One of the advantages of this method is that it includes a series of guides that provide content so that some phases are completed efficiently and, therefore, a final high-level product is designed.

3.3.1 Requirements Template

Requirements elicitation has the objective of producing a requirements specification document that satisfies the user's expectations and the interested parties. For this it is necessary to use requirements collection templates. Durán & Bernardéz (2000), propose templates for obtaining product objectives, functional and non-functional requirements.

3.3.2 Vocabulary, Message and Pictogram Selection Guides

This guide presents a series of considerations for the selection of vocabulary, messages and pictograms to be displayed on the interface. These guides allow you to analyze the situations in which the user needs help; in this way, it is possible to understand the scenario and develop the vocabulary, messages and pictograms appropriate to the situation.

This is possible through some considerations and recommendations proposed by institutes specialized in the domain of AAC.

3.3.3 User Person Template

UIAAC recommends the use of the personal data template. To obtain a UCD, the design must be based on real information about the product's audience, with specific information obtained through user research methods.

3.3.4 Project Management Guide

Every project must be guided by general planning; Bedini & Guerra (2005) propose a project structure composed of a general description of the project that includes the objectives and restrictions; organization of the project, in which the participants and their activities are organized; calendar, containing estimates and a schedule for project tasks.

3.3.5 Usability and Accessibility Criteria

Some usability criteria can be considered for a design to be of quality. Mascheroni & Greiner (2012), Sánchez (2011), and Sastoque et al. (2016) provide usability guidelines (e.g., ease of learning, satisfaction, efficiency, visualization), which will serve as a design guide for the prototype designer.

UIAAC also includes a guide with accessibility criteria, which should be considered to guide the design towards the older persons. Table 1 presents an extract from the guide, with some accessibility criteria.

Table 1: Accessibility Criteria.

Type	Description
Physical accessibility	Consider interacting with traditional media (e.g., keyboard, mouse, touch screens).
Cognitive accessibility	Consider aspects such as language and reduction of users' tasks.
Accesibility visual and motor.	- Text size. - Text style: depends on the user. - Contrast and color - Multimedia: intuitive sounds can be added if necessary.

3.3.6 Organization and Design of Grids

It is essential to consider that a grid must be designed respecting the considerations and specifications of the end-user. UIACC contains a guide with different types of grid organization and design to create a model according to user needs.

4 APPLYING UIAAC

In this section, the five activities involved in the UIAAC method have been applied to design an interface prototype for an AAC web system to assist in communication problems for an older adult. Each of these activities is described at a high level and detailed in Figure 2.

Figure 3 shows the AAC system with its AAC interface implemented. This app is available at the following URL: https://n9.cl/mc3l

5 CASE STUDY

A solution interface was built following the UIAAC method, and it was evaluated through a case study. It follows the following activites proposed in the Runeson et al. (2012) methodology: i) design, ii) ethical considerations, iii) preparation for data collection, iv) collecting evidence, v) analysis of collected data and reporting, and vi) threats of validity analysis.

5.1 Design

This case study's main objective is to know health personnel and end-users perceptions regarding interface pictograms app created for older people. In this context, the research questions are i) How does the psychologist perceive the technological solution's clinical utility? Moreover, ii) How does the end-user perceive the usefulness of the technological. The case study method is holistic-multiple, and the units of analysis are presented in Figure 4.

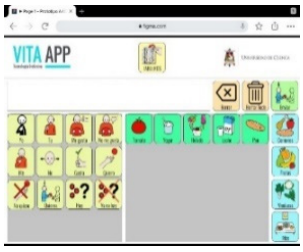

Figure 3: Interface pictograms app.

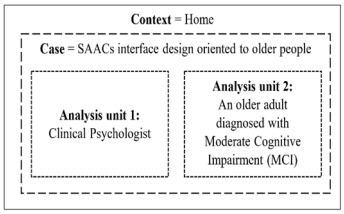

Figure 4: Holistic-multiple method.

5.2 Ethical Considerations

Although Amschler & Pradhan (2001) points out a case study relies primarily on trust between the investigator and the case, some explicit prevention measures have been considered to prevent future problems, mainly because the older adults belong a vulnerable group.

In this case study, the ethical factors considered are: i) informed consent with both the older persons and their primary caregivers, ii) the approval of an ethics committee for this type of test, iii) onfidentiality, and iv) feedback. Moreover, due COVID-19 pandemic context, all health security protocol was considered by the Clinical psychology.

5.3 Preparation for Data Collection

Two surveys have been designed based on the technology evaluation model (TAM) proposed by Davis (1985). This model consists of evaluating the Perceived Ease Of Use (PEOU), the Perceived Usefulness (PU), and the Intention To Use (ITU) in the future. The designed surveys were focused on the elderly and the health expert. This questionnaire, as is shown in Appendix 1, uses a 5-point Likert scale.

5.4 Collecting Evidence

In a first step, the interface pictogram app was presented by the Clinical psychologist to older adult in his home (see Figure 6). Then, the surveys were filled out by all participants.

5.5 Data Analysis and Results Reporting

By analyzing the results, it is found that they allow answering the case study questions. In open questions, older adult agree that the interface is useful for communication. At the same time, the expert considers that obtain new ways to interact with this kind of people is essential for healthy social interaction. Figure 5 shows the overall results of PEOU, PU, and ITU. In general, Clinical

psychologist and older adult mention that the interface solution is easy to understand; besides, this technological input can reduce communication time and effort. They also rescue that it is a useful input since it allows the patient's communication; therefore, it could be used in the future.

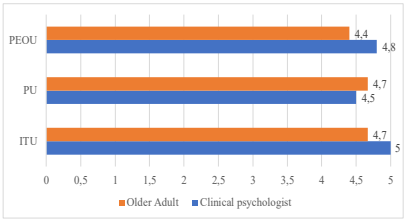

Figure 5: Results of the case study: user perceptions.

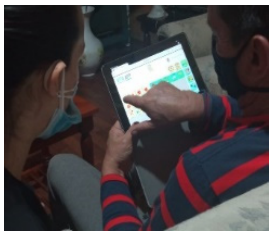

Figure 6: Data collecting.

5.6 Threats of Validity

The following threats to validity are discussed to reveal their potential interference with this study.

5.6.1 Construct Validity

Construct validity refers to the relation between the theory behind the case of study and the empirical reality. To analyze whether the operative measures studied represented what the researchers had planned to investigate and what they investigated. For this step, validated questionnaires were used, which have an ideal Cronbach's alpha; thus, the interview questions' constructs will be interpreted in the same way by the researcher and the people interviewed.

5.6.2 Internal and External Validity

Depending on how the subjects in a group are selected, the selection effects may vary. In this study, the age, pathology degree, and previous experience that the participants have with technology influence the ease of use when using the proposed solution.

For the external validity, the selection of the

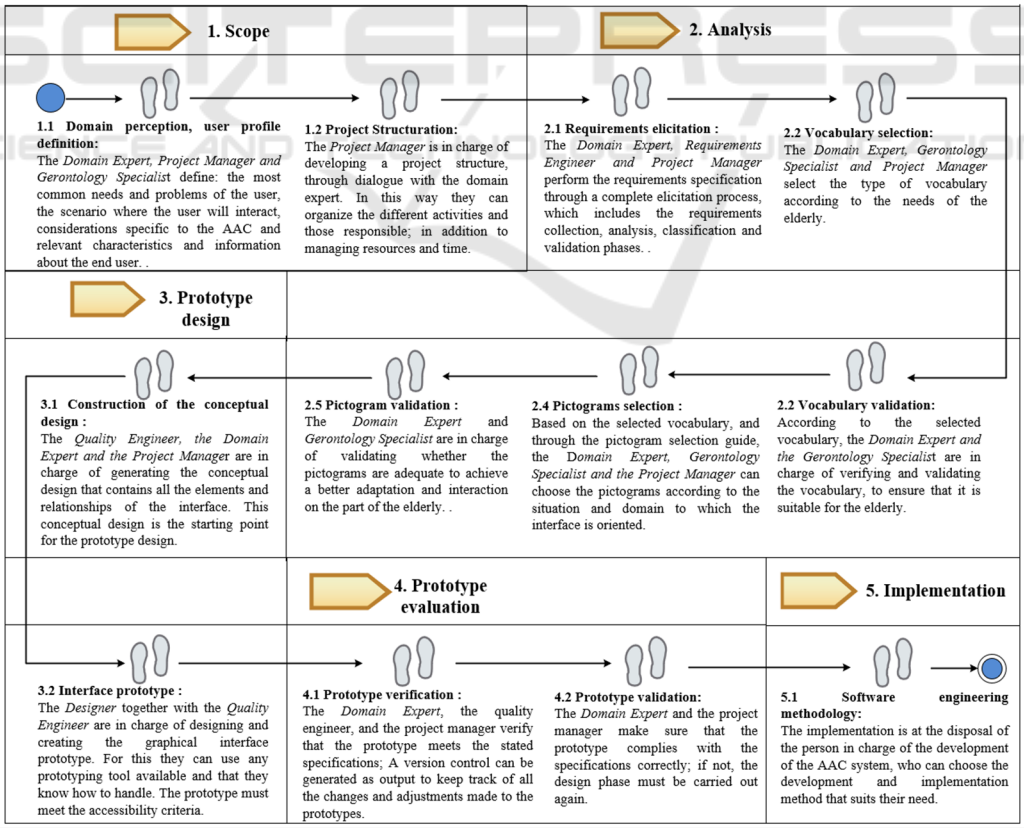

Figure 7: Steps to design a graphical interface for AAC systems using UIAAC.

sample of individuals who participated was made at convenience. Due to the COVID-19 pandemic, access to the elderly population with disabilities is restricted.

5.6.3 Reliability

The evidence chain was carried out respecting the data's literality from the interviews to the analysis. Moreover, the qualitative responses were quantified using a Likert scale to avoid introducing interpretation bias.

6 CONCLUSIONS AND FUTURE WORK

The UIAAC method considers design aspects for older adults based on protocols and standards for designing graphical interfaces for AAC systems that integrate pictograms. The design and creation of prototypes are oriented in the analysis of domains, end-user documents, and observations of the specialist in gerontology; this allows for a correct UCD.

This method is designed to be applied within software engineering processes, specifically for designing graphical interfaces of AAC systems. A web system has been built to help improve older adults' cognitive abilities; where the interface has been designed with this method, it has been possible to test the feasibility of the method. The AAC system has used a psychologist for evaluation and an older adult to use the app. The results show that the app is perceived as easy to use and useful. Finally, as future work, the UIAAC method will be studied in depth to expand and detail each phase's activity, guide, and function.

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REFERENCES

Agudo Prado, S., Fombona Cadavieco, J., & Pascual Sevillano, M. (2013). Ventajas de la incorporación de las TIC en el envejecimiento. *RELATEC: Rev. Latin. de Tecn. Educativa*, *12*(2), 131–142.

Al Mahmud, A., & Martens, J. B. (2016). Social networking through email: studying email usage patterns of persons with aphasia. *Aphasiology*, *30*(2–3), 186–210. https://doi.org/10.1080/02687038.2015.1109051

Amschler, A., & Pradhan, A. (2001). Ethical issues in empirical software engineering: The limits of policy. *Empirical Software Eng*, *6*(2), 105–110. https://doi.org/10.1023/A:1011442319273

Bedini, A., & Guerra, L. (2005). *Gestión de Proyectos de Software*. *1*, 1–191. https://www.inf.utfsm.cl/~guerra/publicaciones/ Gestion de Proyectos de Software.pdf

Beukelman, D., & Light, J. (2020). *Augmentative & Alternative Communication: Supporting Children and Adults with Complex Communication Needs* (5th ed.). Brookes Publishing. https://www.amazon.com/-/es/David-R-Beu kelman-ebook/dp/B08CZ1HRSN

Cedillo, P., Beltran, P., & Rodríguez, P. (2017). Evaluación de la accesibilidad de MOOC orientados a la tercera edad.

Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results. *Management*. https://doi.org/oclc/56932490

Durán, A., & Bernardéz, B. (2000). Metodología para la Elicitación de Requisitos de Sistemas Software Version 2.1. *Informe Técnico LSI-2000-10. Facultad de Informática y Estadística*, 78. http://www.dsi.uclm.es/asignaturas/42541/pdf/metodologia_elicitacion.pdf

Gould, J. D., & Lewis, C. (1983). Designing for usability-key principles and what designers think. *Conference on Human Factors in Computing Systems - Proceedings*, *28*(3), 50–53. https://doi.org/10.1145/800045.801579

Griffith, J., Dietz, A., & Weissling, K. (2014). Supporting Narrative Retells for People With Aphasia Using Augmentative and Alternative Communication: Photographs or Line Drawings? Text or No Text? *American Journal of Speech-Language Pathology*, *23*(2). https://doi.org/10.1044/2014_ AJSLP-13-0089

Hassan, Y. (2015). Experiencia de Usuario: Principios y Métodos. *Yusef.Es*, 139.

Keskinen, T., Heimonen, T., Turunen, M., Rajaniemi, J.-P., & Kauppinen, S. (2012). SymbolChat: A flexible picture-based communication platform for users with intellectual disabilities. *Interacting with Computers*, *24*(5), 374–386. https://doi.org/10.1016/j.intcom.2012.06.003

Labib, C., Hasanein, E., & Hegazy, O. (2009). Early development of graphical user interface (GUI) in agile methodologies. *Journal of Computational Methods in Sciences and Engineering*, *9*(1–2), 239–249. https://doi.org/10.3233/JCM-2009-0251

Light, J., Wilkinson, K. M., Thiessen, A., Beukelman, D. R., & Fager, S. K. (2019). Designing effective AAC displays for individuals with developmental or acquired

disabilities: State of the science and future research directions. *AAC: Augmentative and Alternative Communication*, *35*(1), 42–55. https://doi.org/10.1080/07434618.2018.1558283

Mascheroni, M. A., & Greiner, C. L. (2012). Calidad de software e ingenier{í}a de usabilidad. *XIV Workshop de {...}*, *1*, 656–659. http://sedici.unlp.edu.ar/handle/10915/19202

Matijević, M., Mrvac, N., & Mikota, M. (2014). The effect of expansion and simultaneous contrast in modificated figural dotted and groundal dotted illusions. *The Effect of Expansion and Simultaneous Contrast in Modificated Figural Dotted and Groundal Dotted Illusions*, *21*(6), 1297–1301. https://doi.org/10.17559/TV

Miguel, A. H., Sandoval, C. A. M., De Jesús Pérez Álvarez, M., Yutzil, N., Renovato, L., & Barrios, U. H. (2018). *Diseño de interfaces con tecnología táctil para adultos mayores*. *pp* 79–82.

Office Statistics. (2015). *Eurostat Statistics Explained*. https://doi.org/https://doi.org/2443-8219

Pavlov, N., Castro, M., Chukanska, Y., Molina, C., Mileva, N., & Albetr, M. J. (2018). Mobile Graphical User Interface with People with Verbal Communication Disorders. *Colloquium in Information Science and Technology, CIST*, *2018-Octob*, 391–395. https://doi.org/10.1109/CIST.2018.8596478

Portugal, A. M., Ferreira, D. S., Reis, J. S., Pinho, F., & Dias, N. S. (2013). Cognitive intervention protocol for age-related memory impairments. *2013 IEEE 2nd International Conference on Serious Games and Applications for Health (SeGAH)*, 1–6. https://doi.org/10.1109/SeGAH.2013.6665310

Pressman, R. S. (2010). *Ingenieria del Software. Un Enfoque Practico*. www.FreeLibros.me

Runeson, P., Höst, M., Rainer, A., & Regnell, B. (2012). Case Study Research in Software Engineering: Guidelines and Examples. In *Case Study Research in Software Engineering: Guidelines and Examples*. https://doi.org/10.1002/9781118181034

Sánchez, W. (2011). La usabilidad en Ingeniería de Software : definición y características. *Ing-Novación. Reporte de Investigación*, *2*, 7–21. http://www.redicces.org.sv/jspui/bitstream/10972/1937/1/2. La usabilidad en Ingenieria de Software-definicion y caracteristicas.pdf

Sastoque, S., Narváez, C., & Garnica, G. (2016). *Metodología para la construcción de Interfaces Gráficas Centradas en el Usuario* (pp. 314–324). Nuevas Ideas en Informática Educativa.

Saturno, C. E., Ramirez, A. R. G., Conte, M. J., Farhat, M., & Piucco, E. C. (2015). An augmentative and alternative communication tool for children and adolescents with cerebral palsy. *Behaviour and Information Technology*, *34*(6), 632–645. https://doi.org/10.1080/0144929X.2015.1019567

Tijus, C., Barcenilla, J., De Lavalette, B. C., & Meunier, J. G. (2007). The design, understanding and usage of pictograms. In *Written Documents in the Workplace* (pp. 17–31). Brill. https://doi.org/10.1163/9789004253254_003

Wallach, D., & Scholz, S. C. (2012). *User-Centered Design: Why and How to Put Users First in Software Development* (pp. 11–38). https://doi.org/10.1007/978-3-642-31371-4_2

Waller, A. (2019). Telling tales: unlocking the potential of AAC technologies. *International Journal of Language & Communication Disorders*, *54*(2), 159–169. https://doi.org/10.1111/1460-6984.12449

Walsh, T. (2010). Utterance-based systems: Organization and design of AAC interfaces. *ASSETS'10 - Proc. of the 12th Int. ACM SIGACCESS Conference on Computers and Accessibility*, 327–328. https://doi.org/10.1145/1878803.1878895

World Health Organization. (2011). *World Report on Disability*. https://www.who.int/teams/noncommunicable-diseases/disability-and-rehabilitation/world-report-on-disability

APPENDIX

https://n9.cl/z0st