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How to Develop Information Systems to Improve Accessible Tourism: Proposal of a Roadmap to Support the Development of Accessible Solutions

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Abstract: The right to tourism has become a crucial aspect of society. Through more accessible tourism, it is possible to improve travel conditions for people with disabilities. Nonetheless, barriers still exist, with the lack of information about accessibility conditions representing a main obstacle. Information systems can help overcome these hurdles. However, it is verified that methodologies to support the development of accessible IS are currently very scarce. Thus, this study intends to develop an accessible IS for accessible tourism and propose a roadmap to support the creation of accessible IS solutions. To obtain the intended accessible tourism solution, an action research methodology was followed, which involved adapting already established frameworks, that combine Agile development and user-centered design techniques. Following the methodology, a web application named access@tour by action was created. This mobile solution is capable of improving information management within the accessible tourism market. From this experimental study, a proposal for a methodological roadmap emerged. This roadmap helps to better understand how to develop accessible IS by demonstrating techniques for gathering accessibility requirements and validating them. The roadmap is adaptable and suitable for IS projects involving accessibility. Both results provide a better perspective on how to integrate accessibility during the development of IS, possibly supporting future researchers in creating accessible solutions.

Keywords: information systems; methodology roadmap; accessibility requirements; accessible tourism; user-centered design

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1. Introduction

Improving accessibility conditions in tourism is important to develop a more inclusive society, enhancing tourism for people with disabilities (PwD) and people with other special needs [1]. Accessible tourism can therefore be defined as a collaborative process that intends to provide universally designed tourism products and services, with equity and dignity [2]. In their last disability world report, the World Health Organization (WHO) estimated that 15% of the world's population has a disability, with an increasing tendency [3] due to the aging population. Thus, the accessible tourism market also presents an important economic significance with statistical evidence indicating that by 2020, around 25% of travel and leisure worldwide expenditure would come from PwD [4]. However, despite the extensive literature on tourism experiences [5], a limited number of studies examine the development of Information systems (IS) in the scope of accessible tourism. The lack

of relevant information related to accessibility conditions and poor communication channels [6] are described as major barriers that PwD unfortunately still face when experiencing tourism activities [7]. In addition, the failure to implement information and communication technologies (ICTs) for the accessible tourism market [8] also contributes to inadequate information flow between offer (tourism supply agents), demand (PwD) [9], and educational institutions responsible for training in tourism [10]. Regrettably, this situation may create travel constraints, which tend to be frequently ignored by the different tourism supply agents [11].

To overcome the informational and communicational barriers [12–14] and promote a more accessible tourism, properly developed IS can play an important role [15–17]. According to Kolodziejczak [18], IS on accessible tourism can be seen as software solutions, mostly in the form of a website or mobile technology, that provide information about accessibility conditions in an accessible format to enable decision-making processes related to tourism activities. Notwithstanding, the accessible tourism market is very heterogeneous, as there are different types of specific needs, depending on the situation or particular disability [14]. It is important to note that the accessible tourism market includes PwD (e.g., visual, mobility, hearing, intellectual) but also people with other types of special needs (e.g., pregnant women, people with allergies, people with respiratory and heart diseases) [19]. It is, therefore, necessary to address accessibility requirements, which can be defined as making information and products' overall design simple enough for the majority of users (including PwD) to use without requiring any major adjustments [20]. Within the accessible tourism market, heterogeneity in these requirements is also required, since a person with vision impairments does not have the same needs as someone with hearing impairments. These specific details make the conceptualization of tourism IS a rather difficult task [21]. Besides this, to provide a fully inclusive experience, the needs of all stakeholders of the accessible tourism market should be covered [22]. Therefore, it is of utmost relevance to involve different stakeholders related to accessible tourism in the conceptualization process of an IS to develop this type of tourism.

Previous research studies [23–25] in different areas brought out the need for particular methodological approaches to address users with particular requirements. There is, however, a gap in terms of available IS methodologies regarding the integration of accessibility-related requirements, which may prevent the implementation of IS within accessibility-related markets. Moreover, the lack of understanding of the user perspective can lead to unsuccessful implementations of IS, especially when these systems are designed for very specific audiences [26]. The management and implementation of accessibility requirements is another aspect of tourism IS that needs attention. For the Portuguese tourism market [27], a small number of platforms already exist (e.g., Tourism for all [28]; Hands to discover [29]; Tur4All [30]). A more in-depth examination of current solutions is available in a study performed by the authors and reported in Alves et al. [31]. Essentially, Tourism for all promotes information about accessible tourism for people with physical disabilities by offering information about accessibility characteristics, services available, and distances to airports/health facilities. Hands to discover works as a communication mediator for people with hearing impairments that displays tourism information about places, scheduling, and points of interest in sign language. Tur4all promotes information about accessible tourism in regard to accommodation, restaurants, and recreational activities, presenting an active user community that evaluates scores and comments on issues related to the accessibility of all resources. Notwithstanding, it seems that current solutions present limitations on the integration of accessibility requirements [32]. Furthermore, there is a lack of frameworks for building these types of platforms [33] accompanied by a growing need for accessible tourism IS [34].

It is important to note that guidelines already exist to check whether IS comply with accessibility requirements [35–38], with Web content accessibility guidelines (WCAG 2.0) [39] being the most prominent. Nevertheless, although useful, these guidelines are often introduced in the development process at a very late stage, i.e., after the development is

already done. Additionally, these guidelines only ensure that solutions comply with some accessibility criteria, but do not ensure the representation of user requirements. Due to these factors, traditional methodological approaches in the field of IS [40–45] tend to lack the integration of accessibility features. These existent gaps in the literature body justify the need for developing methodological roadmaps that are able to conduct requirements engineering processes by truly understanding users' requirements within user-centered design (UCD) principles [46]. Note that in this process, it is not only necessary to ensure the accessibility of digital information (communication), but also to ensure that information for specific users is contemplated in the systems [43]. Thus, methodologies that address the needs of the accessible market with highly complex characteristics in terms of functional requirements (referring to the interaction between user and system) and non-functional requirements (referring to software characteristics) will be required [47].

The present study intends to address the above-mentioned gaps in the accessible IS development literature as it seeks to explore a set of recommendations to incorporate into the development of an IS for the accessible tourism market. For that reason, it is intended to explore two objectives. The first is to develop an accessible IS for accessible tourism, and the second is to propose a roadmap to support the creation of accessible IS solutions. To achieve these goals, an action research methodology [48] was applied. This methodology is often used in the IS field because it allows an engagement in research, while also developing real solutions [49]. Hence, this work intends to follow a practical experiment in accessible tourism. The goal is the creation of an IS solution, in the form of mobile technology, for improving information exchange across those involved in accessible tourism. A consequent roadmap proposal emerged from this development. The focus is on the need for guidelines for the development of IS that integrate accessibility aspects, in addition to functional and usability requirements [50]. More specifically, an exploratory participatory approach [23] was chosen with the integration of accessibility requirements. The proposed roadmap can be seen as a great contribution to research works, which aim to implement accessible software. Within this context, the validation of the created framework was achieved by explaining how it was applied in the context of accessible tourism to obtain an IS to develop accessible tourism named access@tour by action.

To achieve the aims mentioned, this paper is divided into four sections. After the introduction that explains the need for methodologies to develop IS in the field of accessible tourism, the first section depicting the theoretical background is presented. The second section explains the importance of IS for accessible tourism, introduces the concepts of UCD, and explores methodological approaches that integrate accessibility requirements in the development processes of an IS. The third section details the objectives and describes the methodology used to develop an IS for accessible tourism. Afterward, the main results are presented. The results are divided into two sub-sections. The first results sub-section is devoted to presenting the developed accessible tourism IS (access@tour by action) by illustrating the solution with some interfaces. The second results sub-section explores the resulting methodological roadmap, which can be used to develop future accessible IS. Then, a discussion section is presented that dwells upon the main academic contributions and the novelty of the article. Finally, the last section explains the possible limitations of the research conducted and future research guidelines.

2. Investigation Background

2.1. Information Systems in Accessible Tourism and Challenges of Their Development

The enhancement of accessibility travel conditions for PwD [51] has become an increasing priority to achieve truly accessible and inclusive tourism [1]. Nonetheless, the accessible tourism market is heterogeneous with very particular requirements [14]. The accessible tourism market is a very important growing market, which must not be ignored by supply agents not only due to social responsibility concerns, but also because of the excellent business opportunity [52,53]. In fact, the accessible tourism market is loyal and economically profitable [4], frequently traveling accompanied and in the low season [54].

The creation of accessible technological solutions should not only focus on PwD, but also on people with other special needs, such as seniors with special needs resulting from the aging process; people with allergies, respiratory diseases, and intolerances; people with extreme morphologies (e.g., obesity); pregnant women and families with small children in prams [2,10]. These special needs could be of a permanent or temporary nature [51] and result in different types of requirements according to the degree of impairment or the type of special needs: accessibility to a physical environment, information regarding accessibility, and accessibility to online information [19]. Because of all of this heterogeneity, in most cases the accessible tourism market is still unknown or ignored by the majority of agents in the tourism industry [1] and many of their needs remain unexplored, resulting in exclusion from tourism and leisure [17]. Even with digitalization allowing for more easy access to tourism information, obstacles regarding accessibility [55] are still prominent. Lack of information about tourism services and products is a big obstacle because it creates travel constraints for PwD.

In regards to tourism offers, PwD need particularly detailed information, especially focusing on their individual/special requirements. In that sense, the higher the accessibility requirements, the more detailed and specialized information is needed [14]. However, as verified by Waschke [56], the supply of specific information becomes scarcer for those with higher accessibility requirements. The difficulty of providing accessible information can make PwD feel unsure about traveling to a given location or taking part in a tourism activity [56]. Consequently, the tourism industry fails to appeal to this group of clients, ignoring possible business opportunities and wasting this large market potential [57].

Access to information is critical not only for people with disabilities but also for every tourist [58]. The possibility to receive information about different features of the tourist destination is a key quality criterion that facilitates every tourist's decision-making and booking processes [37]. Information is considered as essential to create and design informational strategies and accomplish successful tourism practices. The quality of this information is an equally crucial criterion. Inconsistent or contradictory advertising can potentially lead to PwD being disappointed and frustrated to find that in reality, the facilities do not match the descriptions provided [17]. The accuracy and quality of information are therefore very fundamental since more complaints can lower loyalty and overall satisfaction [59]. Wrong information can have a very negative impact on tourism experiences, failing to deliver value and leading to unsatisfied customers. IS can help in this matter, as they are pivotal in making sure that information about accessibility flows within the accessible tourism market [60]. Accessible technologies can, for example, help in searching for personalized tourism offers or even aid in planning accessible routes in a given destination [61]. As technologies in tourism are rising, they have to focus on delivering the right information to tourists with disabilities and make sure this information reaches them. These reasons illustrate the need for conceptualizing simple but accessible types of tourism IS.

As disclosed by Teixeira et al. [32], there are few methodological approaches to developing IS that pay attention to the integration of accessibility details. This is especially true for the tourism market, with no studies being found that address this research area. Essentially, as demonstrated by Nurwidyantoro et al. [62], human values are critical for the development of software artifacts, such as IS. Thus, for an IS to serve the accessible tourism market, it is important to understand its users [63]. In this regard, diverse authors [63–65] suggest the incorporation of three stakeholders within the accessible tourism market: demand agents, supply agents, and teaching institutions. Demand agents include not only PwD but also informal caregivers and social organizations [66]. Essentially, anyone looking for accessible tourism offers should be considered a demand agent [2]. However, it is important to take into consideration that the accessibility market is composed not only from a demand side (PwD) but also from a supply side (tourism supply agents such as museums and hotels). To offer appropriate and accessible tourism offers, supply agents have to be aware of the demands and limitations of the market. Only by integrating the perspective of supply agents, will it be possible to ensure that accessibility information can

flow within the accessible tourism market [67]. Furthermore, for tourism supply agents to offer products adapted to the needs of PwD, future professionals must acquire adequate competencies related to accessibility [68]. Although not immediately obvious, there is a strong relationship between disability, tourism, and education, since educational institutions are the main bodies responsible for providing training in accessible tourism [69]. As demonstrated by Teixeira et al. [65], the specific needs of PwD require adapted tourism products and services, which implies that tourism industry staff must have the knowledge and skills needed to work with the accessible tourism market [10]. Concretely, these stakeholders should be represented by both tourism students and tourism teachers. Students are heavily connected with the learning and future workforce components, while teachers relate more to teaching and research components [68]. For these reasons, one can justify the analysis of teaching institution members (tourism students and tourism teachers) as accessible tourism market elements at the same level as supply and demand agents when developing an IS for accessible tourism.

To integrate accessibility during the conceptualization of an IS, the process of requirement engineering must consider user diversity [70]. This is important because all users of the accessible tourism market (supply, demand, and teaching institutions) should be compelled to be present across the IS development process. This development encompasses stages such as elicitation of requirements, design, and testing [71]. Predominately, and to make sure that the IS works as a whole, users' requirements should be merged with elements of software engineering, usability engineering, and accessibility concepts. This correlation of components is illustrated in Figure 1. Nonetheless, putting users at the center of the development process is necessary for this correlation to happen. Furthermore, while software components will make sure that the solution provides the right functionalities, usability and accessibility integration will ensure that the final version of the system is truly usable and accessible.

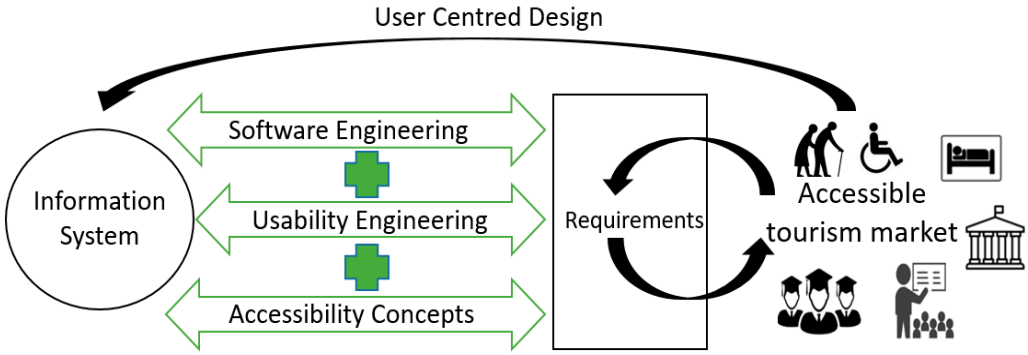

Figure 1. Components in developing information systems for the accessible tourism market.

2.2. Approaches for the Development of Accessible Information Systems

Due to the heterogeneity and complexity of the accessible tourism market, it is not easy to describe and define the diverse requirements for all segments of this market [19]. The complexity [72] of this market is inherent, which makes the development of any technological solution to serve the special case of the accessible tourism market a difficult process. Developed solutions, in the form of IS, should incorporate all of the heterogeneity of this market, which means being able to identify different types of accessibility requirements and their variability according to the degree of impairment and type of users' needs [55,73]. In his regard, concerns over users' perceptions of information technologies led to a change in the focus of methodologies, integrating the user during the development process [74–76]. It has been argued that the lack of human perspective during conceptualization processes can lead to problems, design faults, and difficulties in the implementation process [26], thus UCD approaches were recommended [50]. It has since been stated that UCD is an approach that places an emphasis on users, their needs, and requirements, as well as the application of human aspects, with the goal of making systems truly usable [46]. Conse-

quently, through UCD, it is possible to create technological solutions that support universal access, increasing the standard of accessibility [77].

UCD has already proved relevant in other areas whose domain was characterized by a high degree of complexity, such as healthcare, education, and tourism. For example, In the area of healthcare, Farao et al. [78] applied a UCD methodology based on observations, prototyping, and questionnaires, to create a mobile app to read the results of tuberculin skin tests. Also in healthcare research, Teixeira et al. [75] designed an innovative IS for managing clinical data in hemophilia care, using a methodology that combined UCD with principles of software engineering. In the education sector, Mikhaylova et al. [79] created a student journey configurator platform by integrating students' ideas during the conceptualization and implementation processes. In another investigation related to education, Santos et al. [80] described the creation of customized e-learning environments, which focused the development process around the needs of the students and employing interdisciplinary teams of software engineers and experts in UCD. Finally, in tourism research, Williams et al. [81] created an augmented reality tourism app through UCD, applying semi-structured interviews to gather requirements and creating low-fidelity mock-ups, to enable rapid refinement of the solution. These examples clearly show the incorporation of concepts from both software engineering and usability engineering. These must come together to achieve the main goal, which is to provide solutions that are usable, accessible, and satisfy the users' requirements. Nevertheless, this can only be achieved by incorporating the perspective of the users into the software development process [75,82]. Bearing these concepts in mind, frameworks encompassing UCD [83] can be a crucial aspect in the development of an accessible IS, especially due to the diversity of users and requirements to be implemented into the system.

In the literature, it is possible to find other types of established methodological approaches in addition to UCD. Particularly, in the ICT area, a methodological framework can be defined as a structure that was followed to obtain a given technology [84]. Some methodological frameworks for developing an IS are well-documented [85]. Methodologies such as Agile [40], Soft [41], Kanban [44], and Waterfall [45] can be used as a starting point to develop information technologies. The Agile methodology results from a combination of adaptive methods [86], that starts with a planning stage and goes through a well-established development stage, combining iterative and incremental interactions alongside the project elaboration. The success of this approach led to the creation of the "Agile Software Development manifesto" [87], establishing principles that support the creation of an Agile system development process. The Soft system methodology aims to be an answer to rapidly changing environments [88] by applying a conceptualization process that focuses on retrieving users' requirements, reflecting the environment in which the solution is being created [89]. The use of Kanban methods in software development aims for project teams to have a clear visualization of the workflow at every stage of the development process [90], reducing work in progress and allowing developers to focus on only a few objectives at a given time [91]. Very differently from the other approaches, the Waterfall methodology encourages a linear and sequential development process in which phases are carried out in a consecutively way [92]. Since there is no feedback mechanism, errors detected in late stages can be difficult to correct, which made this approach discouraging to use with developers preferring to follow a more iterative development with Agile methodology [90]. Finally, it is important to note that these are only some examples of methodological processes. Currently, the literature is overflowing with validated methodologies [85], which allow for establishing frameworks and obtaining software solutions. Therefore, before coming up with a framework, developers should carefully think about which methodology best serves the needs of the IS they are creating. This is a crucial factor since the obtained IS solution is greatly affected by its methodological process.

Even with the framework approaches that support the development of IS in different domains, users' requirements are still viewed as the main inputs for building the systems [93]. In spite of that, the development process of these systems can be rather

complex due to the nature of the area where the system is to be implemented. Therefore, the mentioned methodological approaches can be applied to a given context (research area) to obtain actual frameworks for developing IS. With that in mind, in a specific research background, such specific frameworks for IS were created with the purpose of addressing the particular users' requirements of these environments [94]. Studies in areas such as healthcare [23,95–97], education [25,98], and commerce [99] have developed frameworks by focusing on users' requirements. However, there is still a great drawback present in those frameworks: the lack of integration accessibility requirements during the development process. This is confirmed in the literature with diverse studies [100–102] reporting the importance of integrating accessibility in IS, but with no explanation about how exactly it can be done. It appears that accessibility is mostly integrated into requirement assessment and testing phases, as it attributed major importance to incorporating users into the process. Still, these findings indicate the need to increase awareness about integrating accessibility into all developing phases of a solution as studies tend to focus on a specific stage such as testing. Techniques that can include accessibility into all stages of development while also producing transversal notions that can be used with different research bases are currently lacking. This gap needs to be addressed since the disregard of accessibility requirements during a single stage can create a waterfall effect [33], preventing PwD from using eventually obtained technological solutions [103]. Therefore, there is a necessity to create IS developing methodologies capable of integrating PwD from the very beginning of the building process.

3. Objectives and Methodology

The problem that motivated this development was the lack of adequate IS for accessible tourism since, as verified, traditional development approaches tend to lack accessibility features. There is still a long way to go in terms of the incorporation of accessibility requirements in IS methodologies. Hence, the objective is to explore a set of recommendations that can be used to develop accessible IS. To fulfill this objective, it was decided to go through an experimental study of developing an IS in the area of accessible tourism. This innovative system was named access@tour by action.

To obtain the access@tour by action, the methodology followed an action research framework. It was aimed to achieve a real solution through participatory and iterative research methods that address real-world issues [49]. This process involved using methodologies already established in the market and with proven results in other research areas. After reviewing some frameworks, those proposed by Bulao et al. [98], Frost et al. [96], Edelberg and Verhulsdonck [99], and van Kessel et al. [97] were selected and adapted. The Bulao et al. [98] study focused on presenting the results of the development and evaluation of the database system prototype to support the provision of education for students with disabilities. On the other hand, Frost et al. [96] identified the needs, facilitators, and barriers to designing a novel auditory-cognitive training gaming app. A participatory design approach was used to engage key stakeholders across audiology and cognitive disorder patients. Edelberg and Verhulsdonck [99] discussed how accessibility is addressed during the industrial process of developing commerce websites for clients. The authors also introduced a framework for designers in the industry to consider such issues in their work. Finally, van Kessel et al. [97] explored an iterative approach supported by usability testing, to build a mobile application focused on self-management of fatigue for people with Multiple Sclerosis. The iterative approach included various stages of testing, during which user feedback included comments about the interface, navigation, and content.

This selection of these studies can be justified by the fact that the authors followed different methodological processes, which are capable of combining Agile development with user-oriented methods. It is important to note that these studies addressed several research areas (healthcare, education, commerce). The lack of studies in the tourism area justifies the need for this junction of methodologies. Moreover, it is possible to understand that the accessibility focus is once again aimed at just some developing stages such as

testing. The goal is to transfer the described accessibility methodological concepts to tourism. Therefore, an effort was made to adopt and integrate the described concepts within accessible tourism to obtain a new perspective for developing accessible IS. Essentially, the obtained methodology is not only a variant of other research but conveys aspects related to accessibility that were not originally considered but are crucial to tourism. Notwithstanding, there was a need to adjust the methodological frameworks according to the problem under analysis (incorporate accessibility requirements from the users of the accessible tourism market). Besides tackling a software development problem, the methodological approach should value the users of the accessible tourism market. Therefore, it was necessary to accommodate techniques that allowed the potentiation of a greater involvement of PwD and other stakeholders to validate functionalities, in particular, accessibility requirements (e.g., alternative to text content, voice controls, connection with accessibility tools). Therefore, adaptations to the established frameworks were enforced to complement the challenges associated with the retrieval and validation of requirements from PwD. The framework adopted to build the access@tour by action is illustrated in Figure 2.

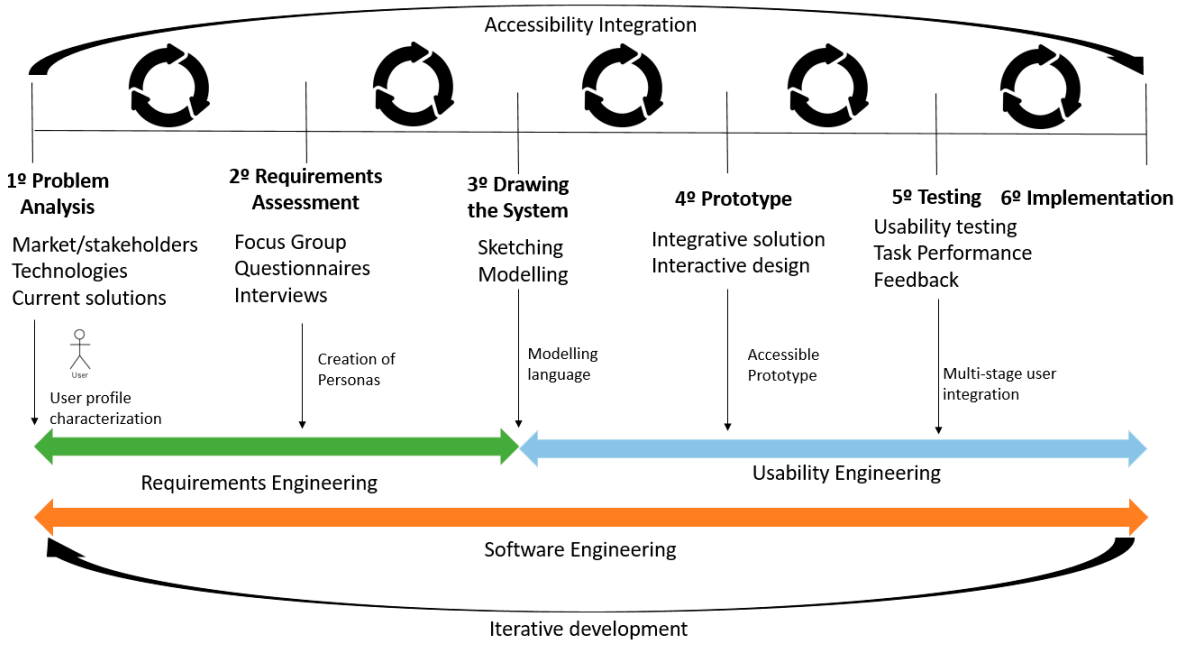

Figure 2. The framework adopted for developing an information system for the accessible tourism market (adapted from Bulao et al. [98], Frost et al. [96], Edelberg and Verhulsdonck [99], van Kessel et al. [97]).

As can be observed, this framework combines different techniques from social sciences areas with tendencies from engineering fields, and incorporating accessibility and users' perceptions as the focus. First, it was necessary to thoroughly study the accessible tourism market regarding its stakeholders, technological development, and current solutions. Concerning the requirements elicitation process, a mix of methods to collect the data, such as focus groups, interviews, and questionnaires were used. However, the diversity of the accessible tourism market [19] leads to the need to characterize every single type of PwD to realize how every type of user can be best served by an IS. A possible solution can be the application of the concept of Personas [104], which can be described as imaginary representations of target users and their motivations, providing information about the users in a more humane, memorable, and interactive way [105]. Thus, a total of nine Personas were created (four Personas characterizing the PwD group; a Persona characterizing an informal caregiver; a Persona representing a social organization (formal caregivers); a Persona representing a museum worker (a Tourism supply agent); a Persona characterizing a Tourism student; and a Persona representing a Tourism teacher).

A very important step was the creation of unified modeling language (UML) diagrams, which led to an evolution of generated data to the visualization of an actual information system. Essentially two diagrams were built: (i) a use-cases diagram, offering an overview of how the users can interact with the system; and (ii) a class diagram, offering a more in-depth look at the type of accessible offers and information available for the users of the IS [106]. These models were evaluated and corrected by experts in tourism and accessibility. Only after this modeling process, was a prototype of the access@tour by action created.

The testing stage applied an innovative mixed-method testing methodology, which integrated the usability principles by Dix et al. [107] such as predictability, consistency, customizability, responsiveness, and, most importantly, accessibility. For this reason, the testing process needed to be precisely planned. Multi-stage testing was a feasible solution, as it allowed the integration of accessibility by eliminating major design faults. Thus, the prototype was first shown and tested with experts in accessible tourism. This allowed for usability and accessibility flaws to be corrected before the prototype reached the end user. The evolutionary prototyping process was then complemented with usability tests amidst potential users. This usability testing procedure consisted of the interaction of users with the prototype to perform pre-determined tasks. An introductory session was conducted by the observers who accompanied the users. Extra care was taken to ensure that the testing area had appropriate physical access. A total of three different metrics were recorded for each task: (i) conclusion rate- was the user able to complete all tasks?; (ii) time- how much time did users spend on each task?; and (iii) difficulty- how easy is the task perceived by the user? At the end, the users also answered a survey. The survey consisted of 33 items that evaluated both usability and accessibility factors, on a Likert scale from 1 to 5. The survey was built based on a compilation of usability measures such as the SUS (System usability scale), SUMI (Standard usability measurement inventory), and WAMMI (Website analysis and measurement inventory). To address accessibility components, the WCAG was also analyzed and incorporated into the testing procedures, with guidelines transformed into question items. A total of 78 potential users tested the prototype. Some of the results are fully disclosed in a study performed by the authors in Teixeira et al. [108]. Overall, the results demonstrated that: (i) the prototype is important and users intend to use it in the future, (ii) the prototype has the right information and delivers it in an accessible way, (iii) the solution is simple to learn how to work with; (iv) the solution provides relevant options for the accessible tourism market. Nonetheless, some feedback was retrieved and the prototype was improved. According to the users, the most complex and time-consuming tasks to complete were the evaluation of tourism offers and the registration procedure. Therefore, these processes should be made simpler and more intuitive. Users also considered that the quantity of information per interface was in some cases not adequate. This affected reading sequence and navigation. This matter was addressed by looking again at how information was disclosed and applying methods to make information appear in a more straightforward manner. Thus, it was possible to improve the prototype and obtain a better user-oriented solution. It is important to stress that the process proved undisputedly important for the validation of system functionalities and gathering feedback about potential improvements, especially regarding accessibility components.

Finally, regarding the implementation phase, special attention will be given to voice assistants. Voice recognition technology and voice assistant software have experienced exponential growth in recent years, enabling users to ask questions and issue commands in their natural language. Some functionalities include sending and reading text messages, making phone calls, providing basic information, setting timers, alarms, and calendar entries, and controlling media playback [109]. Overall, during the implementation stages, an effort should be made to integrate voice assistants within the platform to make sure that access@tour by action is accessible to everyone.

4. Results

Two results have emerged. On the one hand, a prototype of the final conceptualized solution—access@tour by action, and on the other, the transformation of the development experience into a roadmap to help design future accessible IS solutions. To exhibit some functionalities, a prototype for access@tour by action was produced in Adobe XD, following the methodology explained. In addition, in an effort to give a general overview of the solution, some screenshots of the interfaces available in the actual prototype are presented. Afterward, a subsequent roadmap is proposed. The roadmap emerged from the experience of developing the IS for the accessible tourism market, using the action research methodology. This proposed roadmap displays techniques to retrieve and validate accessibility requirements, contributing to the development of accessible IS, and addressing some failures in existing methodologies. The following subsections intend to explore the obtained results and discuss their research implications.

4.1. The access@tour by Action—A Concept of an Information System for the Accessible Tourism Market

The access@tour by action is a web-based information system, which was created to manage information flow between users of the accessible tourism market. The solution takes the form of a mobile platform, as it is intended for use while traveling. The platform appears by following the methodology described beforehand in an iterative format. Essentially, the development process started by analyzing the accessible tourism market and identifying its main stakeholders. Three important stakeholders involved in the accessible tourism ecosystem were identified: (i) Demand agents (PwD, social organizations, caregivers), who are looking for accessible tourism experiences; (ii) Supply agents, who want to offer accessible tourism experiences; and (iii) Educational institutions that are involved in training/learning in this area within tourism, including teachers and students. Essentially, to optimize the solution, besides considering the needs from a demand and supply side, it was also decided to incorporate education institutions because of their involvement with tourism training programs, and their prominence as future professionals. Afterward, a list of requirements for every type of user was gathered using interviews, focus groups, and questionnaires. The requirement assessment phase was heavily user-centered and resulted in a list of requirements for each type of user. Some examples include having access to information in sign language and an easy search for adequate tourism offers for demand agents; easy access to managing tourism offers for supply agents; search for job offers for tourism students; and search for academic investigations for tourism teachers. These requirements were converted into functionalities. To help this conversion, two UML models were incorporated into the design process. This helped mirror functionalities and establish interactions between users. Then, the development of an access@tour by action prototype was obtained by creating interfaces in Adobe XD. Users, via usability testing, tested the diverse interfaces by fulfilling tasks and analyzing their satisfaction. It should be noted that based on the usability tests, the prototype was considered accessible, easy to use, and quite interactive, and the available information about accessibility was very relevant for PwD. Some feedback regarding issues concerning interfaces and functionalities was also gathered, and these issues were promptly addressed and incorporated into the platform. As mentioned before, fully detailed results can be verified in the study Teixeira et al. [108]. This development process allowed for truly iterative and user-centered development, as a continuous improvement cycle was conducted following the obtained feedback.

In an effort to give a general overview, some screenshots of the interfaces available in the actual prototype are demonstrated. As it is not possible to demonstrate all interfaces, the selected interfaces hopefully illustrate how access@tour by action can eliminate accessibility barriers by providing accessible information to PwD about the accessibility of tourism products and the destinations themselves. The access@tour by action incorporates information to meet the needs of the diverse identified stakeholders (Figure 3). The different points of view from the users bring general benefits to IS development, particularly because

it obligates the consideration of different perspectives, especially regarding accessibility matters. This integration also makes it clear that access@tour by action is innovative and distinct from other tourism platforms.

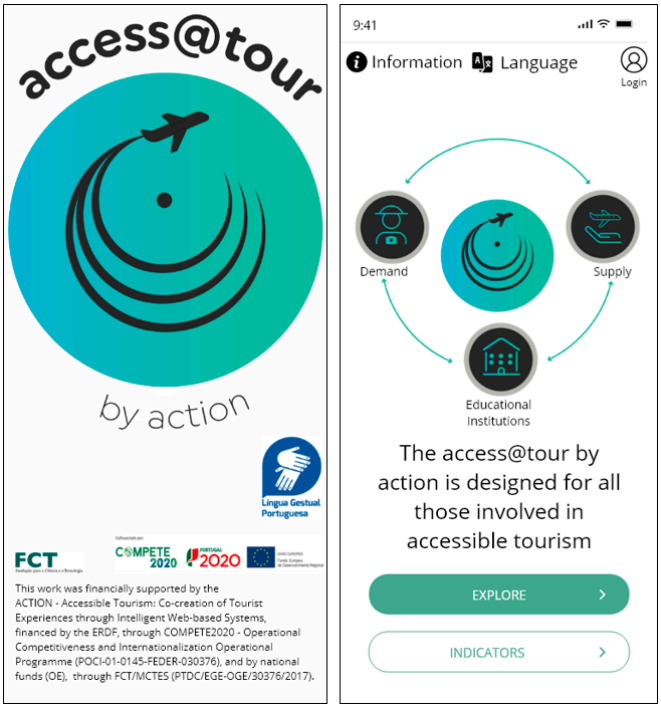

Figure 3. Interfaces of the access@tour by action home screens. On the left, the initial interface of the prototype. On the right, the entry menu highlights the dynamic interaction between demand agents, supply agents, and training institutions.

Based on the gathered information, it was possible to design and implement system functionalities. There are four paths offered according to the type of user. Once a navigation path is selected, it is possible to better specify the type of user and to navigate with a set of information oriented to that user profile (Figure 4). For demand agents, the access@tour by action essentially allows users to easily search for barrier-free tourism offers. It is also possible to evaluate previous tourism offers, search for accessibility support services, and search for laws on accessible tourism. Additionally, demand agents can create a profile that specifies particular accessibility requirements, narrowing the search for more personalized tourism products. For supply agents, the platform is designed to help promote accessible tourism products by allowing these users to enter their offers into the system. Moreover, the system also permits the management of inserted offers, finding tourism support activities, looking for qualified human resources, finding accessible tourism projects and financial support, and registering job offers. In the case of teaching institutions, the functionalities are a little bit different for tourism teachers and tourism students. For tourism students, the system supports the entry of their curriculum vitae (CV), search for employment vacancies in accessible tourism, look up training opportunities related to promoting accessibility in the travel industry, and explore accessibility research studies on accessible tourism. On the other hand, for tourism teachers, the access@tour by action allows them to look into accessible tourism training programs and explore academic-level research, investigations, and projects, as well as financing opportunities to research projects in this field. Information about employment opportunities (such as university teaching careers) can also be found. Additionally, this type of user has the option of uploading their CV to the platform and contacting students to work on research projects. Finally, it is important to mention that there are functionalities available to all types of users. Some examples include a chat interface for user interaction, a notification alert page, access to some fundamental system

definitions, and a home button for quick access to the user's homepage. These options are available through a toolbar located at the bottom of each interface. It was intended that this toolbar be a quick way to navigate the access@tour by action.

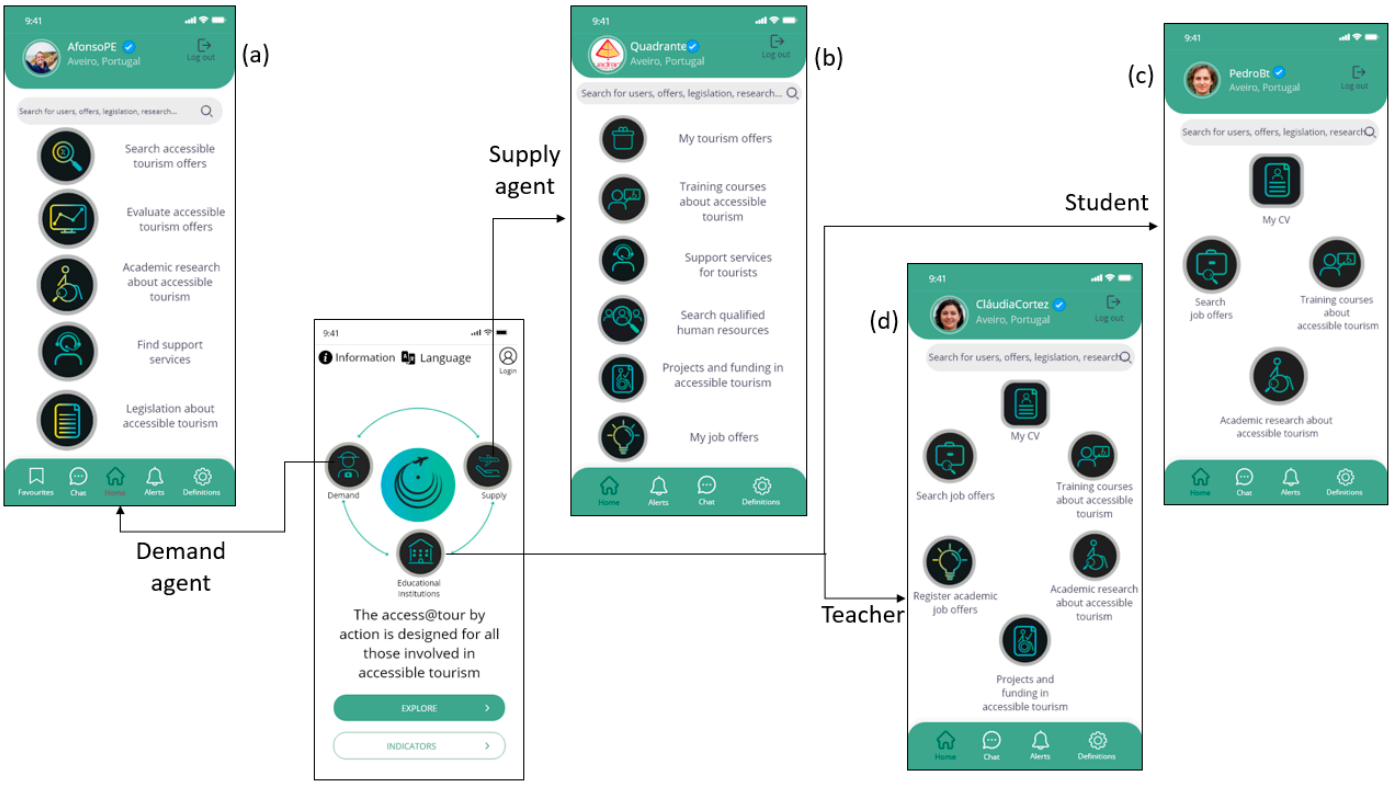

Figure 4. Interfaces of the different functionalities. From left to right: (**a**) functionalities for demand agents; (**b**) functionalities for supply agents; (**c**) functionalities for tourism students; (**d**) functionalities for tourism teachers.

Aside from the interaction explained above, and given the development context, it was also necessary to ensure that the system was indeed accessible. Thus, some accessibility functionalities (non-functional characteristics) were also implemented within the access@tour by action (Figure 5). As expected, these functionalities were mostly developed to cater to the demand side. However, it can be affirmed that a more accessible platform can benefit all types of users since everyone can benefit from more accessibility conditions. Some of these functionalities include: (i) a presentation of the content of the platform in sign language, (ii) the possibility to resize the text, (iii) audio alternatives for content with text, videos, or images; (iv) a straightforward navigation system; (v) the presentation of content in an easy-to-understand format; (vi) a clear layout; and (vii) support for assistive technologies.

The conceptualized solution was designed with the intention of being adaptable and open to innovation. The needs of all stakeholders served as an example to illustrate the complexity of accessible tourism. The described solution was elaborated to eliminate travel constraints in the accessible tourism market, improve the skills of its workers, and enhance the accessibility of the tourism products and the information available to PwD. The first version of access@tour by action was tested and validated, with a complex usability testing procedure. However, the implementation phase is still ongoing. The integration of new technologies, namely Tourism 4.0 concepts will lead the solution from concept to reality. Furthermore, an effort was made for the system to comply with WCAG 2.0.

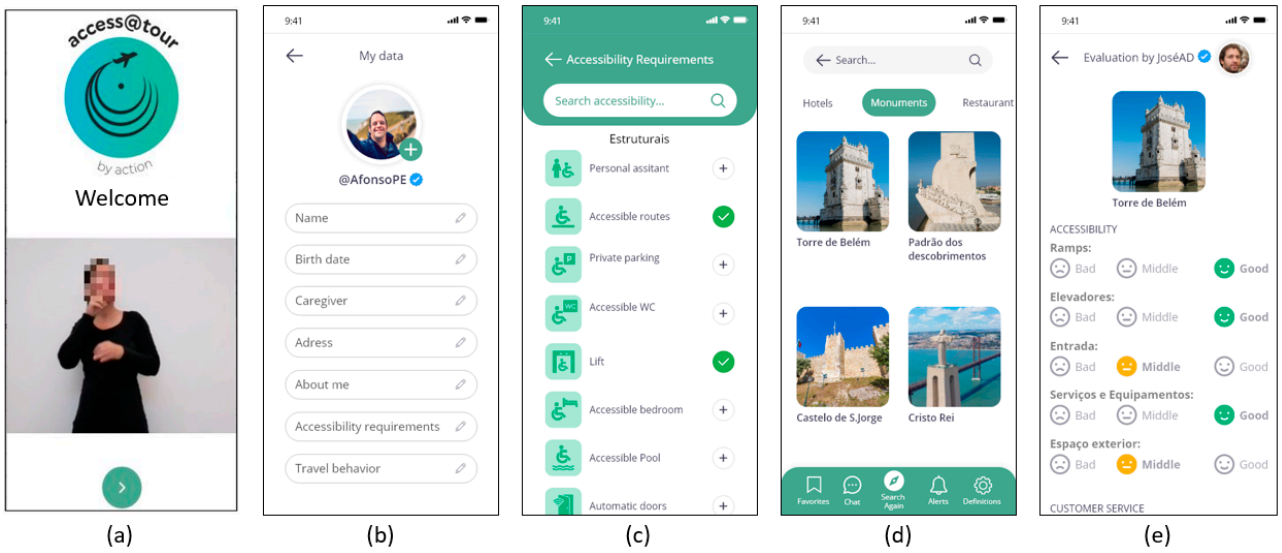

Figure 5. Interfaces of different implemented accessibility characteristics. From left to right: (**a**) screen with video and sign language support; (**b**) user profile building; (**c**) users' introduced accessibility requirements appear automatically while searching for a tourism offer; (**d**) offers view interface with audio description; (**e**) the interface available for evaluating tourism offers in a simple format.

4.2. Proposed Roadmap for Developing Accessible Information Systems

The roadmap presented here is the result of a development experience based on a methodology already established in the software engineering field. Since it was a methodology oriented to a general audience, it was necessary to adjust certain steps due to the importance of involving specific audiences, namely PwD. This is how the methodological roadmap emerged, integrating diverse development phases with techniques for gathering accessibility requirements and validating them. The proposed roadmap is illustrated in Figure 6. This roadmap is presented as an iterative model, divided into six stages, which are then grouped into three very distinct phases: (i) exploratory; (ii) development; and (iii) implementation.

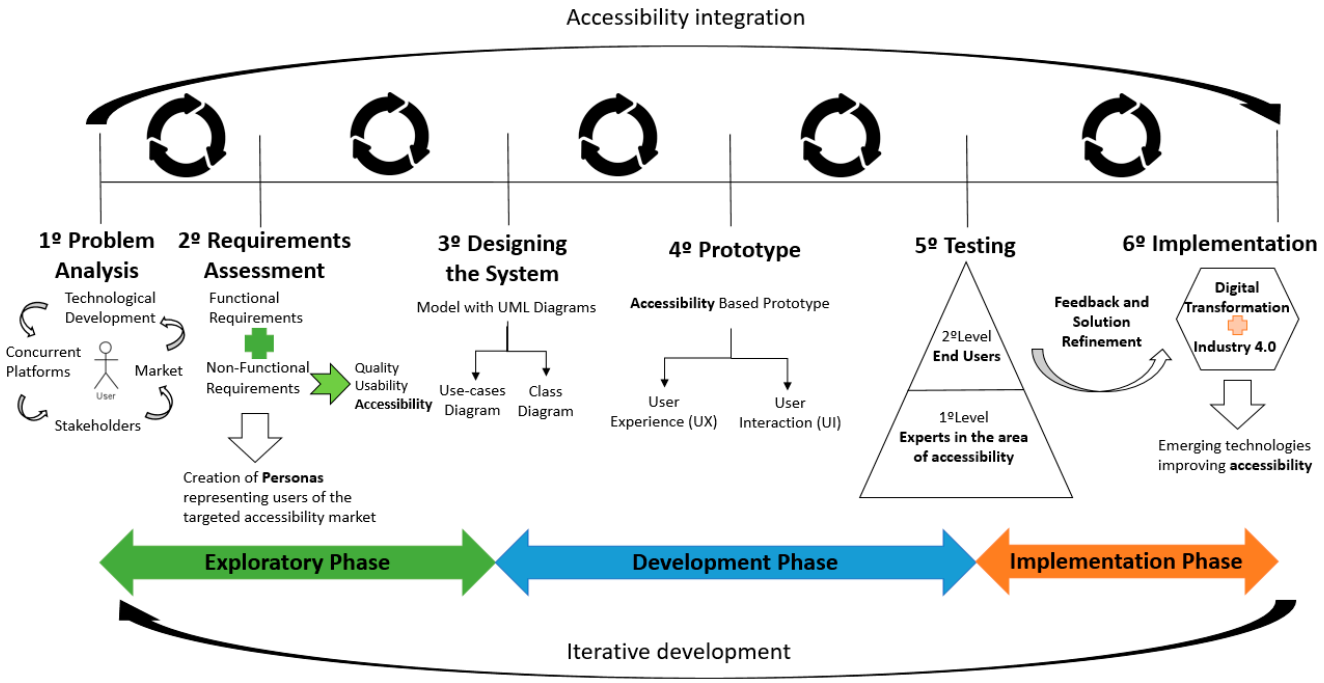

Figure 6. Proposal of a methodological roadmap to develop accessible information systems.

The exploratory phase must include a problem analysis and assessment of requirements. The first stage of the process consists of analyzing the research area (e.g., healthcare, education, tourism) and accurately understanding the environment/market in which the solution will be created. To this end, it is imperative to conduct benchmarking research, by investigating the current state of technological development, stakeholders, and existing solutions. After this initial process, the probable diversity of the market generates the need to collect both functional and non-functional requirements from every single type of potential user (e.g., PwD, caregivers, supply agents, and social organizations).

The requirement elicitation process needs to be carefully planned, as the solution will be designed with very specific users in mind. The interaction between the user and the system is dictated by functional requirements, therefore the task of collecting such requirements gains special importance. Due to this particularity, an UCD approach englobing every single type of stakeholder is necessary. Finding strategies for addressing the requirements of a specific type of market is important. The needs of a given set of users may be different, so several strategies can be applied to generate a better idea of the needs of a particular type of user. To realize how every type of user can be best served, a participatory design process (interviews, questionnaires, focus groups) can be applied to obtain an in-depth understanding of the targeted market and retrieve functional requirements. Essentially, it is necessary to look at the specific needs of each type of user and formulate deep rational thinking on how the IS can become a solution to their requirements.

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Regarding non-functional requirements, special attention must be given to the concepts of quality, usability, and accessibility. As stated, the lack of incorporating such notions can lead to failures in the development of IS. Essentially, it is important to collect requirements related to how ICTs work in accessibility environments [9]. To achieve such a goal, accessibility studies should be performed, based on the standards provided by WCAG 2.0 [110] and national and international accessibility laws [111,112]. In addition, different ICTs (e.g., websites and mobile apps) can be explored to identify major flaws in the provision of information to PwD.

After gathering all requirements, it is important to carefully study them. Thus, the list of requirements should be interpreted as inputs to commence the conceptualization process. Hence, based on the requirements, the design and construction of the IS can start. Notwithstanding, the integration of the requirements within a technological solution remains a complex task. In this regard, creating Personas (imaginary representations of targeted users) can be helpful. Within UCD approaches, Personas can aid developers in

better understanding the users, help in projecting how the IS can become an actual solution for their needs. This better perception can clear confusion on how the solution should be designed.

The development phase includes the steps whereby the system is developed, tested, and rebuilt. After collecting the requirements, the system now needs to be designed. For the designing stage, UML can be used. UML is a standard language for specifying and visualizing IS and developing conceptual models. With the representation of the system in these two diagrams, a better idea of the capabilities and functionalities of the system can be transmitted. UML is a very important design language in large projects when it is necessary to communicate with potential developers. Even so, it can be difficult to understand by potential users. Moreover, other UML diagrams besides use cases and classes can be used. Objects, collaboration, and sequence UML types of the diagram can be considered when creating the data-driven models, to specify systems' particularities.

After completing the data model and the interaction model, the development of the prototype can be carried out. This development should occur from a user-experience and user-interaction point of view, with special attention to the integration of accessibility. The software in which the prototype will be developed needs to be decided, upon consideration of the complexity of the design and the requirements to be implemented. In addition, it is important to ensure that the software is capable of integrating the accessibility functionalities, which were previously identified. The prototype is a great tool to present and share solutions with users. Regardless, as part of an evolutionary development phase, a flexible type of prototype (capable of being modified) should be considered. In addition, depending on the context and characteristics to implement, the right selection of software to develop the prototype is critical. Depending on the functionalities to be implanted, a specific software may be better than others. Hence, developers should give this matter proper thinking.

Posterior to obtaining the prototype, the evaluation task is another very important step. Due to the complex nature of accessibility research, an innovative UCD method including several evaluation cycles was assembled. This was intended to guarantee a solution aligned with the needs of users. This testing phase intends to be an iterative process, with the procedure being implemented across two levels and integrating a solution refinement procedure. The first level refers to testing with accessibility experts. This first evaluation is intended to assess the prototype in terms of content, usability, and accessibility. Through tests with experts, it is possible to identify critical errors in the platform, such as errors in language and the way information is presented and delivered. After this process, the solution should go through an improvement process, eliminating the identified flaws. The prototype can now advance to the second level of the testing stage. Within this second level, usability tests should be carried out with potential end-users, evaluating three factors: information, interaction, and accessibility. The focus will be on hearing from users about the IS prototype and perceiving if there is a correct user-platform interaction. Overall, usability tests with task performances and simple questionnaires can be applied to obtain feedback and improve the solution according to users' recommendations. It should be noted that more testing cycles with experts or users can be needed. Each development team should establish validation goals to advance. Some examples include established usability tests' metrics, but researchers can also create their own achievement targets. Consequently, only after a correct validation, should the prototype advance to the implantation phase. Integrating the users and usability testing is a very consistent way to improve the solution. Their feedback is essential to understand if the solution really answers their needs and requirements. Nonetheless, when testing with different users, distinct usability tests may be necessary. This is especially important when different audiences evaluate the prototype or when users need some type of assistive technology to test the solution, as is the case, for example, of people with visual disabilities.

In the implementation phase, it is recommended to look at how recent technologies can help improve the accessibility of developed IS solutions. It can be particularly important to

integrate concepts of digital transformation and Industry 4.0 [113]. In this regard, voice assistants, automatic recognition, and internet-of-things [114] are possible examples of technology that can be implemented and create both innovation and accessibility. In this latter stage, it will also be essential to study how the prototype can be implemented in a real-life context. This is necessary to identify potential difficulties that may arise and estimate potential costs. Ultimately, the roadmap should then have created a technological and accessible IS solution, proving its value for future research, within the accessibility scope.

By presenting the ensuing roadmap, the intention is to demonstrate the practical applications within a methodological context and unveil a path for future practitioners to develop accessible IS. Moreover, it is possible to verify that accessibility concepts have been present in the methodology since the very beginning. This is crucial, as one of the pointed-out methodological failures was exactly the integration of accessibility in only some development stages. Notwithstanding, another aspect should be considered. Despite the roadmap being obtained with a practical study in accessible tourism, it provides crucial concepts that can be replicated in a generality of research areas, as long as accessibility and the requirements of PwD are the main concerns.

5. Discussion

The study of methodological processes for building accessible IS is a very important procedure to guarantee that PwD have access to technological solutions and that those solutions can answer their requirements. In the particular case of accessible tourism, there is a great challenge in developing IS solutions. This is mainly related to the diversity of needs of tourists with disabilities, which is an excellent example of the inherent complexity of accessible markets. This complexity is associated with the fact that there are different types of users and consequently, a huge diversity of accessibility requirements. Regardless of its importance, very little attention has been given in the literature to the topic of integration of accessibility in IS development methodologies, with accessibility-related concepts being often introduced in the development process at a very late stage. Consequently, there is a need to create methodological approaches to accessibility markets, that understand user requirements and integrate accessibility across the diverse stages of the development of an IS. To address this gap, the present study explored what methodology procedures should be incorporated in the development of accessible IS. An action research methodology was followed, combining different methods that integrate accessibility requirements as main components. The novelty of this study lies in the two main results: a concept of an IS solution, named access@tour by action, and a proposal of a methodological roadmap. The access@tour by action should be interpreted as a solution to improve the flow of accessible information across different users of the accessible tourism market. The demonstrated interfaces (Figures 3–5) illustrate how exactly accessible solutions can function in the context of accessible tourism. On the other hand, the subsequent roadmap (Figure 6) was obtained based on the experimental study. The proposed roadmap implicates a new perspective on established UCD approaches by integrating iterative and progressive design techniques to retrieve and validate accessibility requirements. Both the access@tour by action and the proposed roadmap present a set of recommendations to incorporate into the development of accessible IS, fostering the development of these types of solutions.

The insights obtained in this study will hopefully contribute to the creation of more accessible and sustainable technological solutions with the practical study highlighting some perspectives that need to be embraced. Regarding theoretical contributions, it was possible to study different concepts inherent to the integration of accessibility requirements. In that sense, approaches such as UCD were combined with user integration methods and established guidelines, in an effort to further improve accessibility practices. Thus, it was possible to develop knowledge regarding methodological approaches for creating accessible technologies. Both results (the solution and consequent roadmap) should be seen as pathways to develop accessible IS. More specifically, the creation of the access@tour by action intended to explore how to address accessibility requirements by addressing the

integration of users from the beginning of the IS development process. This integration demonstrates why the access@tour by action application differs from existing accessible tourism solutions. The main difference lies exactly in this integration of diverse stakeholders. In general, existing platforms (e.g., Tourism for all; Hand to discover; Tur4All) only focus on sharing information about the accessibility characteristics of tourism offers and most only focus on one type of disability. Moreover, only tourism demand and tourism supply agents are involved in these platforms, leaving out educational institutions that, as has been emphasized by the literature, have a fundamental role in accessible tourism. The scope of action of the current platform is limited, thus access@tour by action highlights a novel and effective approach to address the accessible tourism market. Moreover, the obtained roadmap can be seen as a way to build accessible IS, helping researchers, designers, and front-end developers create accessible solutions for PwD. What is different and innovative about the roadmap compared to established methodology procedures is the incorporation of techniques to identify and validate accessibility requirements. The goal is for future designers and developers to truly understand how to incorporate users' requirements, during the conceptualization of an IS. This is crucial, since their integration may be pivotal to building solutions, capable of answering the most complex accessibility requirements. Thus, it was also possible to obtain important practical contributions to the tourism industry, more specifically shedding some light on how to improve accessible conditions for PwD.

For correctly assessing the potential of the roadmap and the access@tour by action, it may be necessary to perform a complexity analysis of the system's architecture and algorithms. Thus, it is possible to use the performance analysis to describe the computational key functions within the system, especially those related to data processing and accessibility feature implementation. As verified with the usability testing, the system seems to be well-received and easy to use. It also provides the right content about accessible tourism and is relatively accessible. As was intended, the solution does not have a very complex architectural design, since it was designed for an accessible audience. Notwithstanding, it is also possible to identify optimization opportunities within the system. For example, the roadmap can be further enhanced by integrating an Artificial Bee Colony Optimization Algorithm [115]. This integration can potentially enhance the roadmap by providing a method to efficiently organize and personalize tour schedules for PwD. Overall, this example of an optimization approach can directly contribute to making the access@tour by action more responsive to the specific needs of users, addressing the requirements of diverse PwD. Thereby, this integration is capable of improving accessibility and user satisfaction.

Another important discussion point is to envision how the proposed roadmap can be adapted for use in other domains beyond tourism. The answer may lay in state-of-the-art works such as the "Interreg E-Chain Project" [116] and "Accessible Heritage Cities" [117]. The Interreg E-Chain project's approach to gathering the needs and preferences aligns with UCD philosophy, showcasing the importance of personalizing experiences to accommodate PwD. Accessible Heritage Cities aims to increase historical towns' accessibility while also encouraging the growth of sustainable tourism and the preservation of cultural assets. These examples clearly demonstrate that the primary objective is to enable PwD and their families to fully participate in recreational and cultural activities. In addition, these studies' synergy demonstrates how the creation of universally accessible environments is crucial for PwD. The proposed roadmap can be integrated within these accessible environments to expand its scope and create accessible technology solutions in other research areas, supporting the mentioned works. Besides this projected integration, some characteristics of the roadmap were built to work in other domains besides tourism, as accessibility remains the main focus. The requirement-gathering process to build technological solutions can be applied in the contexts of health and education for example, as it involves validated methods to gather inputs from PwD. As for building and testing an eventual solution, some small adaptations can be applied, allowing researchers to use the roadmap in other domains. For example, instead of experts in accessible tourism, testing with experts with

backgrounds in accessible education can allow for the roadmap to be applied in contexts of education technology development. Notwithstanding, it is essential to focus on how these integrations and adaptations can collectively advance the development of accessible conditions through innovative information systems and inclusive experience customization.

6. Conclusions

Even though the obtained results contributed to expanding knowledge on the development of accessible IS, some limitations should be contemplated and addressed in future works. Firstly, it is important to note that due to space constraints, it was not possible to explain in detail all of the processes used to obtain the access@tour by action. As a future work, it is hoped to fully explore the platform and its development by focusing on how the interviews/questions were designed to obtain the requirements, describing the sample and population to contextualize the research. It will be also necessary to fully explain the usability testing procedure and analysis of respective results. Accessibility is a major issue, and for that reason, there is a need for testing methodologies capable of integrating accessibility components. Thus, as future work, it is intended to address these issues by demonstrating a testing framework capable of truly comprehending accessibility requirements and correctly gathering feedback from PwD. In addition, it is important to stress the fact that the access@tour by action is still a concept. Even though a prototype of the solution has been developed, the implementation stage is still ongoing. Therefore, it may be crucial to address concepts such as flexible architecture and design, as during implementation, strategies may arise that require modification and/or expansion of the IS without major overhauls or interruptions to current functions. Furthermore, the implementation stage will be heavily influenced by new emerging technological concepts, such as Tourism 4.0. As possible further work, it will be necessary to study the impacts of Tourism 4.0, especially in the accessibility field. This will provide important details about how emerging technologies such as artificial intelligence and virtual reality can be integrated within access@tour by action. To achieve this, it may be necessary to perform a systematic literature review to identify technological drivers (e.g., virtual reality, augmented reality, artificial intelligence) to understand their potential to create more accessible tourism conditions. This can guarantee that the solution becomes rather innovative but still accessible to users. Another possible limitation of this work is that the proposed roadmap was created by using only one experimental basis, in this case, accessible tourism. So, there is a need to apply and test the roadmap in other areas. As mentioned beforehand, there are details in the proposed framework that when adapted, can make the roadmap work in other specific research domains. In addition, the proposed roadmap demands active collaboration from different users, which could lead to increases in terms of complexity and systems' development times. Notwithstanding, even though the experimental study tackled the accessible tourism sector, it is intended for the roadmap's concepts to be replicated in diverse accessibility contexts. Ultimately, there should always be room for improvement. In light of these factors, it would be interesting as future work to apply the roadmap in other areas such as education and healthcare. In these areas, accessibility also seems to be a key issue. This would allow the validation of the roadmap, applying its concepts to address distinct users' accessibility requirements, thus obtaining accessible IS solutions.

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