Mobile Navigation and Information Services for Disabled Students in University Buildings: a Needs Assessment Investigation

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Abstract. Mobile technologies may be helpful to support students with disability in navigating buildings and accessing useful services in higher education facilities. However, the design of appropriate mobile solutions depends on knowledge of the actual needs of disabled students, and is made difficult by the lack of contributions in the literature about the point of view of disabled students on their experiences and difficulties in the higher education environment. This paper reports results of an interview-based study we carried out with 14 disabled students in our university. The study led to the identification of significant issues related to navigation of university buildings, access to supporting information services, and relationship with mobile information technology. In the paper, we discuss these issues and their possible impact on the design of mobile systems for disabled students that support indoor navigation and service provision in university buildings.

Keywords: Disabled students, indoor navigation, mobile devices, needs assessment, design implications, location-based services

1 Introduction

Today, mobile technologies give the opportunity to better support students with disabilities in higher education, providing access to tools, applications, and services that can help disabled students to overcome some of the barriers they encounter in their educational facilities. In particular, mobile devices can be helpful in supporting indoor navigation, simplifying the search for resources (e.g., lecture halls, offices, easy access bathrooms, elevators, special equipment, etc.) within university buildings, while taking into consideration the specific needs of different categories of disabled students. Moreover, mobile devices can provide anytime, anywhere access to other information services (e.g., real-time lecture timetables, emergency notification, people finding) that might be useful to support the daily educational activities of students.

In recent years, a growing amount of research has focused on location-based services (e.g., navigation support, monitoring, event notification) for people with disabilities, especially in the case of visual impairments. Most of the contributions are technical in nature, exploring different technologies and proposing architectures, interfaces, systems for the disabled (e.g., [1–5]). However, there is a general lack of investigations about the point of view of disabled people on their experience and difficulties in academic environments. While current works are typically informed by common sense knowledge of the needs of specific categories of disabled users, a more specific viewpoint would be extremely useful to help system designers better understand the real needs of disabled students and the implications of the introduction of specific technological solutions.

This paper reports results of an interview-based study we carried out with 14 disabled students (mostly, with motor and/or visual disability) attending undergraduate or graduate courses at our university. The interview was aimed at investigating issues that students experienced with respect to navigation of university buildings, access to (or lack of) information that might be helpful during academic activities, relationship with mobile information technology. Insights obtained can be used to inform the design of mobile systems for disabled students that support indoor navigation and service provision in university buildings.

In the following, we first briefly provide background on disabled students support in higher education and navigation support for people with disabilities. We then describe our study and selected findings, highlighting design implications for mobile navigation and information services. We conclude with final remarks and future work.

2 Background

In the past two decades, legislation such as the Americans with Disabilities Act (US, 1990) or the Disability Discrimination Acts (UK, 1995, 2005) have stimulated interest in supporting disabled students in higher education. This led to the definition of strategies on how to ensure law compliance as well as policies and guidelines for teaching activities with disabled students [6]. Some studies have been aimed at understanding the experience of disabled students in higher education, especially from the point of view of the student. However, such studies mostly deal with barriers to entry to higher education, issues related to attending lectures, coursework and examinations (i.e., core learning activities), or social issues with staff and other students [7].

Investigations of the role of mobile technology in supporting higher education for students with disabilities have been scarce, limited only at exploring how to provide access to assessment tools, learning materials and tutor support [8]. Instead, much research work has been aimed at designing mobile navigation systems for people with disabilities, both for outdoor and indoor use. Most of this work has focused on the exploration of different localization technologies (e.g., GPS, RFID tags, dead-reckoning sensor-based solutions, etc.) and on the investigation of appropriate presentation of navigation instructions (e.g., audio-

based, vibration-based, etc.), especially for users who have a visual or cognitive impairment [1, 9]. For example, Marco and colleagues [2] propose a system based on ZigBee and ultrasound positioning to provide location-based services such as alerting, navigation, and mobility training to elderly and disabled people. Ko and colleagues [3] present an indoor wayfinding system for the visually impaired that is based on a combination of scene analysis (to determine the current situation) and pictograms or color codes detection (similar to barcodes and QR codes) to help the users recognize their location and find their way to a given destination. Yang and colleagues [4] describe a smartphone application for travelers with visual impairments that uses GPS, WiFi, and a compass to determine the user's location and supports generalized spatial awareness by making the environment more legible (i.e., easy to map mentally) and simplifying spatial information access. Montague and colleagues [10] propose a mobile indoor navigation tool that makes use of a shared user model to customize the route to a given destination based on the user's wayfinding capabilities, preferences, and interaction needs. Several other similar works have been presented in the literature (e.g., [5, 11–13]).

In general, most of the above mentioned works are technically-oriented and draw on results of previous technical studies and/or common knowledge of the needs of disabled users. Few of the works specifically investigated the point of view of disabled users and their needs in terms of navigation support and service provision prior to system design. For example, Quinones and colleagues [14] conducted formative interviews with visually impaired people before starting design of their application [4]. This revealed requirements and suggested ways of implementing appropriate location-based systems.

3 Method

We conducted interviews with the goal of eliciting requirements and design implications for the development of mobile systems that provide disabled students with access to navigation support and other useful information services in university buildings. We recruited 14 (6 male, 8 female) undergraduate or graduate disabled students enrolled in different programs. Seven students had different degrees of motor disability, 3 visual disability, 1 dyslexia, 2 multiple disabilities (motor and visual). Candidates were first contacted by our university office for disabled students assistance. Those students who agreed to participate in the interview were then contacted by phone by a member of our research team to briefly explain the goal of the interview. We also sent an e-mail to all participants, explaining in more detail the topics of the interview. Interviews were conducted in a large and accessible meeting room and lasted 30 to 50 minutes. In 5 cases, the student was accompanied by his/her helper, who listened to the interview. In those cases, we also collected feedback on the discussed topics from helpers. All helpers were female. Interviews were semi-structured and involved questions on 3 main topics: difficulties students encountered in navigating university buildings (including knowledge and previous experience on procedures to

follow in the event of emergencies such as fires or earthquakes); information, not directly related to navigation, that students needed or would have liked to get to support their activities when in a university building; use of mobile technology (including types of applications, assistive technologies and preferred information presentation methods). When appropriate, additional questions were asked to clarify dubious points or explore interesting sub-topics. We audio-recorded all interviews and took notes to capture reflections of the interviewers and inform further questions as we followed up on topics of interest that arose during the interview. Interviews were then transcribed and analyzed.

4 Findings

In this section, we describe core themes that emerged across our interviews with respect to navigation, information access, and mobile technology, as well as the opportunities they suggest for design.

4.1 Navigation barriers

In general, students identified several barriers to their movements but the level of importance given to specific barriers varied according to the type of disability. Stairs were impassable barriers for wheelchair students, significant to mild barriers for other motor-impaired students (who would use them only if no alternative path was available) and mild barriers for visually impaired students (who would use them to shorten the path towards a destination). Small isolated steps as well as doors were a significant nuisance (but not an impassable barrier) for all motor and visually disabled students. Motor-disabled students complained about the complex structure of some of the university buildings, which contained small spaces, twisted paths, and small elevators that were difficult to access. On the contrary, visually impaired students complained about the presence of large empty spaces in buildings, which made it difficult for them to orient due to the lack of physical references. Partially sighted students also mentioned they had problems when navigating scarcely lighted and uniformly colored areas. Often, due to unexpected events such as temporarily inaccessible areas or sudden schedule changes, students had to search for alternative barrier-free paths to reach places.

These findings provide compelling motivations for the introduction of a system that provides personalized path generation by taking into consideration the specific type of disability of a student. More specifically, the need to cope with multiple context factors such as time constraints or real-time events (emergencies, schedule changes, etc.) calls for the implementation of a mobile system rather than a solution based on pre-planning accessible routes on desktop computers. Our findings also help to clarify the nature of architectural barriers and how these should be managed in a navigation system. Almost every student we interviewed introduced new types of barrier (including elements, such as “empty

space" in the case of visually impaired students, which are not typically associated to the concept of barrier) and it is thus clear that a navigation system must be flexible and allow its users to define new barriers and barrier categories. Indeed, some students suggested that the integration of a location-aware function to help them report barriers within buildings would be extremely helpful to inform other students and the university administration of potential problems. We also found that a barrier is not always a binary concept (no barrier/impassable barrier) but a multi-level concept where the level might depend on factors such as availability of alternative paths to a destination or the student's personal assessment. Designers of navigation systems should thus restrain from artificially setting the importance level of a barrier but let users define their own constraints.

4.2 Navigation knowledge acquisition

The main strategy students used when they did not know how to reach a specific place within a building was to ask a knowledgeable person, mainly porters or other students. However, sometimes indications were vague or erroneous, or did not take into consideration the specific disability, thus leading students along barrier-laden paths. Navigation in some of the buildings was slightly simplified due to the availability of situated displays informing students about the timetable and halls where lectures were held during the day. However, these displays did not provide instructions on how to reach specific places. While maps of the buildings were typically available at main entry points, students pointed out that they did not make use of them because of their complexity, due to the high amount of information crammed in too little space. Moreover, maps were totally inaccessible to visually impaired students. From the point of view of the evolution of navigation knowledge over time, most students claimed that after a few times they had experienced a given path, they were able to memorize it and had no subsequent problems. However, problems emerged each time they had to travel outside their usual paths to reach unknown places such as teachers' offices. Since students did pay little attention to their surroundings during navigation in a known environment, they did not build sufficient environmental knowledge to determine alternative paths when these were needed. A few students claimed to have limited spatial ability and to depend upon others for guiding them to places even if they had been there before.

These findings further confirm the likely helpfulness of a mobile navigation system for indoor navigation compared to more traditional solutions such as asking other people or reading physical maps. Students would be able to obtain personalized indications without having to depend on possibly inappropriate or difficult to understand sources of information. Our findings also reveal opportunities for integration of multiple electronic sources of information like mobile devices and situated displays. An additional advantage of a mobile navigation system is that it can monitor student's usual paths and, from time to time, suggest alternative paths to destinations to improve environmental knowledge, thus reducing users' difficulties in case of unexpected barriers. Similarly, mobile devices can be used to replace human-based training activities of helpers, which

are rare and often constrained in the amount of information they can provide in their allotted span of time. Helpers would thus be able to get instructions about the structure of buildings, possible barrier-free paths, location of lecture halls, operation of assistive technologies such as ramps, and behavior to keep during emergencies, thus providing better support to disabled students.

4.3 Need for physical and informational resources

During their daily activities at the university, disabled students had often difficulties in accessing needed physical and informational resources. Students mentioned mobile desks for the disabled and electric plugs (to charge their computers or mobile devices) as examples of physical resources that were hard to locate within buildings. Access to these resources often required external human intervention which was not always available. With respect to informational resources, students complained about the modalities with which they were notified about timetable or hall changes for lectures. Notifications were provided in widely different ways, depending on faculty and teacher, and included paper notes posted on lecture hall or teacher office doors (the worst for visually impaired students), e-mail, web notes on the faculty or teacher website, SMS messages, phone calls. Apart from the difficulty in checking different sources for information, late notifications of lecture changes created serious logistic problems to those students who were not autonomous with respect to transportation. Typically, students were able to access information they needed such as administrative documents through their faculty website but there were often difficulties with access to contact information and event notifications (e.g., seminars, optional learning activities). In the first case, students often relied on porters or the office for disabled students assistance to get what they needed; in the second case, they had to personally search for posters or paper notifications of the events posted somewhere around the university.

These findings highlight that a mobile navigation system should not only support disabled students in reaching specific places within buildings but also help them search for and access physical resources that are needed to carry out academic activities. Moreover, a unified mobile notification system for the different types of academic-related events (e.g., lecture changes, seminars, etc.) would be an extremely helpful asset to improve the academic experience of students.

4.4 Relationship with mobile technology

All students we interviewed had a mobile phone. The type of phone ranged from low-level feature-phones with only communication capabilities to smartphones with rich computational capabilities. Visually impaired students used phones with speech synthesizers or magnification devices. While most students used the phone for voice and SMS communication, some of them accessed mobile services to get useful information such as train timetables. There were also instances of students exploiting their device to study course materials in digital form, avoiding the need to carry with them laptops or paper documents. Almost all students

preferred push-button phones to touch-based phones and gave two main reasons for this: 1) push-button phones provide physical feedback which is considered very important (current feedback provided by touch-based phones, e.g., through vibration or speech, is deemed still insufficient and cumbersome, even if research is actively working on the issue [15]); 2) fear of dropping (and breaking) the phone due to limited motor control. All motor-disabled students stated that they do not use the mobile phone while moving and expressed concerns about the use of solutions that would require them to look at their device to get information while moving. Visually-impaired students used the speakerphone when they needed to navigate options on their phones or read short messages (e.g., SMS) but expressed no opposition to the use of earphones during movement provided only one ear is involved (due to their need to sense the environment).

These findings revealed students' familiarity with mobile devices, even if mostly limited to communication purposes. Yet, there is a willingness to use new technologies and mobile services if these provide significant benefits to the student. Preference for push-button phones implies the need to develop interfaces that accommodate different input modalities and to carefully investigate the acceptability of currently mainstream touch-based solutions. Given disabled students' difficulties in using mobile devices while moving, visual-based solutions for the presentation of navigation information to sighted users should be carefully designed to require only minimal attention from the user and be possibly secondary to other means of presentation. Visually-impaired students would benefit from the availability of audio or tactile-based systems that provide guidance to reach the resources available in the places they enter, but such systems need to require low cognitive resources in order to have a minimal impact on environment sensing.

5 Conclusion

In this paper, we discussed selected results of interviews we held with disabled students in higher education, aimed at assessing their experiences and needs with respect to navigation of university buildings, access to supporting information services, and relationship with mobile information technology. Results of the analysis of interviews highlighted implications for the design of mobile navigation and information services for students with disabilities. They will be used to guide the design of a prototype mobile navigation and information access system that will be deployed and evaluated at our university.

6 Acknowledgments

We acknowledge the financial support of the Italian Ministry of Education, University and Research (MIUR) under Law 17/1999 within the project "Ausili elettronici alla navigazione degli utenti disabili all'interno di sedi universitarie".

We are grateful to Luciano Picone and Cristina Disint (Centro Orientamento e Tutorato, University of Udine, Italy) for their precious support in organizing the interviews.

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