A Model of Web-Based Follow-Up to Reduce Assistive Technology Abandonment

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Abstract. The abandonment of assistive technology (AT) is strictly related to the subjective quality of the service delivery regarding the whole AT assignation process. Starting from this consideration, the aim of this work is to show the design of a Web-based follow-up model (WFM) aimed at overcoming the hearing aid abandonment in the Italian Umbria Region AT service delivery system. The WFM model described here is developed in two phases: an implementation phase, and an experimental evaluation which is still under development. The model meets the current objective of the Umbria Region's Units of Local Health Service to digitize their services in order to easily monitor the quality of the delivery service and evaluate the post-provision outcome.

Keywords: Assistive technology abandonment, assistive technology system delivery, assistive technology outcome, follow-up.

1 Background

The literature on assistive technology (AT) claims two main factors affecting AT abandonment: the perceived user interaction with the device and the quality of the AT service delivery process as experienced by the user. In particular, the first factor depends on: (i) how much the user's needs have been met; (ii) the extent of the psychomotor skills needed to use the equipment; (iii) the attributes of the AT's functioning; and/or (iv) training and support provided during and after the AT delivery. If one or more of these aspects of interaction with the AT is perceived as problematic, users tend to abandon the device. The second factor, regarding the quality of the AT service delivery as experienced by users, during and after the assignation process, was found to be strictly correlated with AT abandonment: the more the problems experienced during and after delivery, the more users are likely to abandon the AT.

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In Italy, Federici and Borsci [1, 2] systematically analyzed the two factors described above, in order to estimate the rate of AT abandonment and to clarify the relationship between this rate and user satisfaction regarding the AT delivery systems in the Umbria Region local health service. Findings showed an average AT abandonment rate equal to 19.09%, which was lower than the average AT disuse, usually estimated in Western countries as being one third one year after from the device delivery [1-7].

In particular, the lowest level of abandonment (12.26%) was related to ATs delivered within a well-designed process of assignation, focused on the users' needs. In contrast, the highest level of abandonment (24.34%) concerns those devices, such as stairlifts and hearing aids, provided by those AT service delivery systems that are much more focused on reducing the costs of public spending. These latter systems are also characterized by not providing a follow-up service [1, 2].

Moving from these pivotal results, the aim of this work is to discuss a Web-based follow-up model developed to overcome hearing aid abandonment in the Umbria Region AT service delivery system (SDS).

2 Method

The overall aim of this work is (1) to analyze the Umbria Region AT delivery process and (2) formalize a Web-based follow-up model (WFM) for hearing aids and prosthetic services.

The methodology adopted involves the qualitative analysis of AT user experience by means of a user-centered web system, created in order to easily monitor the quality of use and user satisfaction. The study is structured into two phases: (1) WFM design and implementation; and (2) WFM experimental evaluation with end users. Phase 2 is still under development.

2.1 Phase 1 – The WFM Design and Implementation

Phase 1 consists of the engineering process of a WFM that is consistent with the Umbria Region AT SDS.

Phase 1 is divided into the following activities:

- Investigation on current hearing aids assignation and delivery models of the Umbria Region AT SDS, and design of a single and integrated follow-up model.
- Design and implementation of an accessible and user-centered Web-based follow-up system.

Investigation on Umbria Region Hearing Aids Assignation Models and WFM Implementation. The Umbria Region AT SDS is organized into two units of local health services (ULHS). For each one of them, the current hearing aids delivery process consists of four phases: (i) a first-user audiometric test to evaluate whether the user matches criteria for a hearing aid assignation. Then, (ii) the otolaryngologist defines a range of hearing aid models suitable for the patient's needs and initiates a trial period. In this period, (iii) the patient is given one month to test the different models suggested by the otolaryngologist in specialized centers. When the patient has identified the preferred aid, (iv) a second audiological visit is scheduled with the

otolaryngologist who evaluates the appropriateness of the product selected by the patient and prescribes the AT. The prescription guarantees a full refund of the cost of the hearing aid by the ULHS.

Starting from the analysis of the current Umbria Region hearing aids assignation models, a new model was implemented to integrate them with a post-provision Web-based evaluation ideal process. The WFM proposed here uses an evaluation protocol assessing the subjective experience of both delivery process and quality of AT use by means of five questionnaires.

The questionnaires were administered immediately after the AT delivery and after three and six months. Two questionnaires measured the AT quality of use: the Assistive Technology Use Follow-up Survey (ATUFS) and the Abbreviated Profile of Hearing Aid Benefit (APHAB; [8]). Two questionnaires measured the user's perception of disability: the World Health Organization Disability Assessment Schedule 2.0 (WHODAS; [9]) and the Hearing Handicap Inventory Adult/Elderly (HHIA/E; [10]). Finally, the Quebec User Evaluation of Satisfaction with Assistive Technology 2.0 (QUEST; [11]) measured the user's satisfaction regarding both the AT delivery process and the product.

Implementation of a Follow-Up Web Portal. The implementation of a web portal called www.laregionetisente.org was carried out on the basis of a user-centered design model, which is a set of design procedures based on end users' needs. This process included (1) a prototyping phase, and (2) a system development phase. Phase 2 has been conducted alongside the iterative evaluation of the system.

1. Prototyping Phase

The web portal provides an interactive area to monitor patients with hearing impairments.

Domain Model and User Types. The main types of Web users include patients, otolaryngologists, and staff members.

- *Patient.* The interactive area allows patients to fill out a series of questionnaires aimed at monitoring the use of the prosthetic devices. Patients can fill out each questionnaire independently or with the help of a doctor or a staff member. The access to the system is limited to only authorized people. Patients may access their data at any time. The web portal can be accessed via a Web browser on any desktop computer or on any mobile smartphone or tablet.
- *Otolaryngologist.* The otolaryngologists who collaborate with the project can access the interactive area of the web portal to monitor the progress of their patients. They can enroll new patients and fill out their questionnaires. They can also view test results and data from the follow-up.
- *Administrators.* The staff members can access patient data for analysis and research, perform online tests for the follow-up process, access the patients' profiles in order to contact them directly. Administrators can also obtain some statistics and download test results in Excel format for further, more detailed analysis.

Use Cases. The use cases identified for each type of user are described below:

— *Patient*

- Homepage information reading;
- Website registration (social security number, phone or e-mail address to receive notifications, password, full name, municipality of residence);
- SMS reception;
- Mobile app download;
- Test answers insertion (APHAB, ATUFS, Base Test, WHODAS);
- Test results' visualization.

— *Otolaryngologist*

- Website registration;
- Patients' registration;
- Patients' test answers insertion (Base Test, HHIE, HHIA);
- Prosthesis data insertion;
- Patients' monitoring and test-reports printing.

— *Administrator*

- Information content modification (on the information area and the interactive area);
- Patients' registration;
- Patients' monitoring;
- Otolaryngologists' management;
- Data management and exportation;
- Test definition;
- Patients' test answers insertion (APHAB, ATUFS, HHIE, HHIA, Base Test, WHODAS) if the patient has not yet compiled it;
- Test report download;
- Database design.

The following description is a high-level overview of the database developed for the system. The UML class diagram is illustrated in Figure 1; each class represents one of the main entities in the data model.

Figure 1 shows two major categories of data: the first is to model the system's users, and the second is to handle the patients' tests. The most crucial classes of the model are described in more detail below.

Modeling Users

The high-level modeling of the user is implemented using the abstract level class VitaUser used to save the data common to all user types. The user profile (Profile class) may be of three types:

— Patient
— Otolaryngologist
— Administrator

Although at this stage of the project there are only otolaryngologists that manage patients, the system is designed to be extended in the future to all types of physicians. Notice how the administrator has the ability to enter information content into the system (Entry and Tag classes).

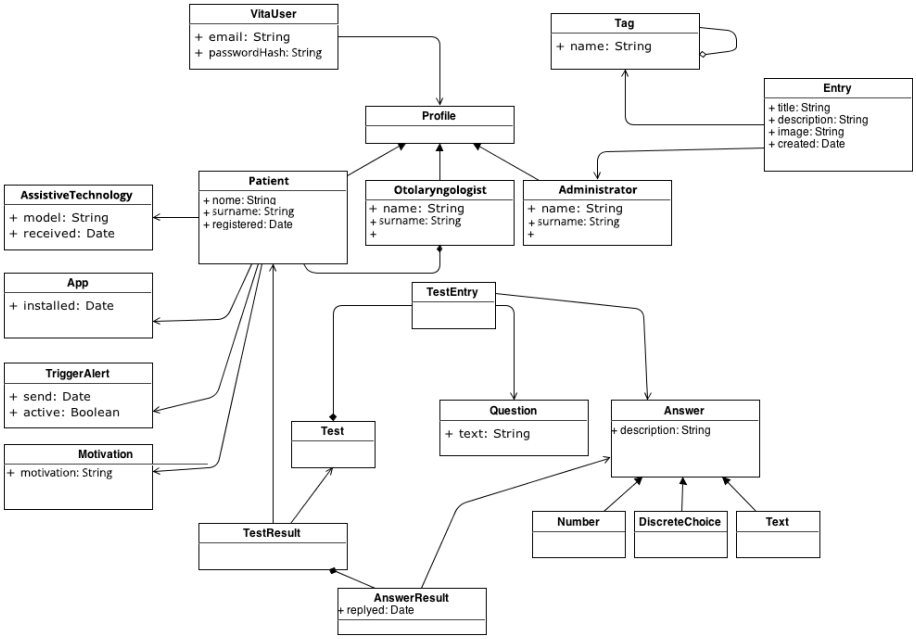

Fig. 1. The database UML class diagram

Modeling Tests

A structure that abstracts the concept of the questionnaire has been defined, so to cover all possible kinds of answers to questions, such as numerical, YES/NO, or open-ended answers. A high level of abstraction was provided to easily extend the system in the future, while still allowing the full implementation of the use cases and the questionnaires related to the management of hearing prosthesis.

Each questionnaire (Test class) consists of a pair question-answer (TestEntry) and the answers can be of different types: YES/NO, multiple choice or open. When a questionnaire is presented to the patient, an example of the test result (TestResult) is created, which contains the answers of the test (AnswerResult).

Architecture and Technology Infrastructure

The system has been designed to be easily extended in the future and to be able to handle hundreds of thousands of patients. In this section we will describe the architecture of the system and its infrastructure.

MVC Client-Server Architecture

The system was developed using well-established architecture: MVC client-server architecture (Figure 2). This architecture plans to divide the system into three levels for both the client and the server parts: the Model, which deals with persistent data in the database; the View, which displays the data; and the Controller, which coordinates the interaction between the View and the Model.

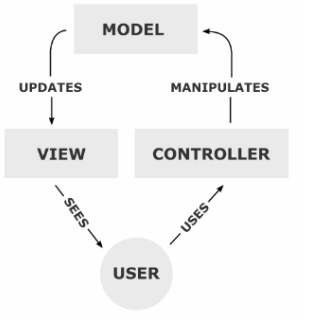

Fig. 2. MVC Client-Server Architecture

Cloud Infrastructure

In order to develop a system that can be extended in the future to monitor additional AT, the system has been designed to effectively manage hundreds of thousands of users. We decided to implement Cloud technologies to achieve a high level of scalability in the future. In particular, we opted for the Windows Azure infrastructure. The server part consists of a variable number of Worker Roles, which the load balancer, i.e. the system responsible for redirecting the requests, manages autonomously according to the load. The database has been implemented using the SQL Azure infrastructure, which supports up to hundreds of GB (gigabytes) of data with a high level of reliability. SQL Azure also directly backs up the data and secures the accesses. With such an architecture, in the future it will be possible to extend the system to support an increasing number of patients.

2. System Development Phase

The system was developed using an *Agile* methodology. The development has been divided into seven iterations, each consisting of a set of small features immediately available online. Each iteration has extended the system from time to time, up to the final version now available on the portal laregionetisente.org. The iterative method allowed us to proceed step by step, by adapting the features to the real needs of the users.

The system user-centered evaluation used the following human-computer interaction tools and methods:

- Quantitative analysis of accessibility by using the WAVE Toolbar for Firefox v. 1.1.7.
- Quantitative analysis of accessibility by using the Firefox Accessibility Extension v1.5.6.
- Cognitive Walkthrough. This is the simulation, by one or more expert evaluators, of the behavior of an inexperienced user interaction with the interface. The qualitative analysis method allows the identification of any issue that is supposed to occur in different scenarios of use.

At present, the system is implemented according to the main international standards on accessibility and following the usability principles and guidelines that are currently adopted by the international scientific community.

In order to ensure the highest quality for the system, we decided to develop the system starting from the tests (unit tests), according to the TDD methodology (Test-Driven Development). The development was divided into seven stages. The first phase focused on the information blog, while the subsequent phases addressed the design of the interactive area. All stages of development are listed in Table 1. The subjective end-user experience evaluation of the product version 1.0 will be completed by the end of 2014.

Table 1. Stages of system development

Phase	Module
1	Administrator registration module Blog Module for inserting information useful to the patients
2	Patient registration module Otolaryngologist registration module
3	Aiding device registration module Data management and exporting module
4	Notifications module
5	SMS notifications module
6	Tests definition module Test-filling module (user/administrator)
7	Smartphone mobile app Monitoring module

2.2 Phase 2 –WFM Experimentation

Phase 2 consists of the investigation of the user's needs and satisfaction regarding the prosthetic delivery service during and after the provision of the AT. This phase is conducted through the web portal that was implemented in Phase 1.

Procedure. Phase 2 is developed by the following three activities:

1. Patient recruitment and data collection. Subjects were informed about experimental purposes, procedure, and terms of the experimental process. A short interview collecting demographic information and medical history (HHIA/E) was conducted and digitized in the www.laregionetisente.org web portal by the otolaryngologists.
2. Qualitative evaluation of user's hearing aid experience. A qualitative evaluation was conducted during the AT testing and 3 and 6 months after the AT delivery. Five questionnaires were administered to assess the quality of use of AT (ATUFS and APHAB), user's perception of disability (WHODAS and HHIA/E) and the user's satisfaction of both process and product (QUEST). At any time, users are allowed to access their personal area, monitor their questionnaire results and the information on their own satisfaction in the AT use, and consult an overview of their follow-up appointments provided by the Health Service.
3. Data analysis and effectiveness investigation of the WFM.

Results. Sixty-one subjects (54% males and 46% females) were recruited. At the time of the first audiological examination, 11.4% of patients (57.1% males) were aged below 65 years and were then interviewed by using the HHIA questionnaire, while the remaining 88.6% (53.7% males) were older than 65 years and received the administration of the HHIE questionnaire. Eighteen out of the total patients enrolled required a renewal of the hearing aid license while 30 were requiring a first prescription. Data related to the outcome of the AT assigned are still being processed.

After the AT delivery, patients obtained their private login data to access their interactive profile and to fill out the subjective satisfaction and quality of use questionnaires (see activity 2). Results obtained through HHIA/E questionnaires show that 85.2% (55.7% male) of users have a "severe disability" and 14.8% (44.4% male) a "mild moderate disability." Activity 3 is currently under development.

3 Conclusion

In line with the Umbria Region's goal to digitize ULHS, WFM helps to overcome the limitations of the current hearing aid delivery process, which still follows paper-based procedure, making it difficult to monitor the quality of the delivery service and evaluate the post-provision outcome. Based on information technology, the WFM is easily manageable through a Web platform (www.laregionetisente.org): An accessible system was implemented through an interactive user-centered design process, whose usability has been constantly improved by UX methodology [12]. WFM provides a support and monitoring service, by which both professionals and patients are constantly informed about the delivery process. WFM allows otolaryngologists to easily check the patient's profile and set up and manage their appointment schedule. The patient's profile contains all related demographic information, medical history, and appointment schedule, which the physician can constantly update. Likewise, patients can read their clinical assessment outcomes and be provided with a reminder service, keeping them constantly up to date with their appointment schedule and hearing aid delivery status. Moreover, WFM returns the hearing aid perceived quality of use and satisfaction of each patient immediately after the aid has been delivered and three and six months later. This follow-up information is automatically digitally processed, based on data obtained through five questionnaires self- or interviewer-administered.

The model presented here can help to improve the appropriateness of national health-care services [13, 14] while at the same time increasing patient satisfaction. As improved training and support, and a reduction in problems experienced during and after the AT delivery process are correlated with AT abandonment, we expect that WFM might reduce the abandonment rate. In this way, our model can not only drive down costs but also avoid the economic meltdown caused by inefficient health-care systems.

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