Assessment of Ambient Assisted Living Services in a Living Lab Approach: A Methodology based on ICF

Ana Isabel Martins[1], Alexandra Queirós[2], Margarida Cerqueira[2],
Joaquim Alvarelhão[2], António Teixeira[3] and Nelson Rocha[4]

[1] Institute of Electronics and Telematics Engineering
Campus Universitário, 3810 Aveiro, Portugal

[2] Health Sciences School, University of Aveiro, Campus Universitário, 3810 Aveiro, Portugal

[3] Dep. Electronics Telecommunications and Informatics, IEETA, University of Aveiro
3810 Aveiro, Portugal

[4] Health Sciences Department, University of Aveiro
Campus Universitário, 3810 Aveiro, Portugal

Abstract. A major problem inherent to the development of Ambient Assisted Living (AAL) products and services is its assessment and validation. It's crucial to involve the users in the validation/development process. In a Living Lab approach, the validation of AAL products and services is focused in user's needs and preferences, integrating their daily lives and social roles. The International Classification of Functioning, Disability and Health (ICF) arises as a conceptual framework to develop instruments for the evaluation of AAL products and services. In this sense, the purpose of this paper is the description of an evaluation methodology of AAL products and services in a Living Lab approach based on ICF.

1 Introduction

Ambient Assisted Living (AAL) refers to concepts, products or services that connect and improve new technologies and social systems, in order to promote quality of life of all people during all stages of their lives [1]. The AAL emerged from a European Union initiative that aims to meet the elderly population growing needs, which represents nowadays a major concern in terms of sustainability [2]. AAL enables the utilization of products and technologies and the provision of distance services including health care, helping to achieve autonomy, independence and dignity [3]. These characteristics make AAL appropriate to fulfill those needs, yet this paradigm is inclusive and universal, so it favors not only the old people as well as all others whether they have a limitation or not [3]; [4].

A major problem inherent in the development of AAL products and services is its validation. Only through validation it's possible to assess the adequacy of the products or services to their users, identifying problems and developing guidelines for

users and developers [5]. The evaluation of these products or services is usually made according to the usual approach. Normally, specialists are responsible for the idea, design and development of technologies, deciding what functions and services to integrate and how users interact with them. User's needs, experiences and mental models are, in general, not considered from the beginning, only at a later development stage.

Thus the concept of Living Lab arises and it represents an innovative approach in which development process all interested parts in a service, product or application are involved [6, 7]. The main difference between usual research programs and Living Lab approach is the involvement of users, in their daily lives context, embracing and integrating all their social roles [6]. This method allows a more realistic validation centered in the user.

The utilization of AAL products and services aims to improve people's participation and performance in carrying out activities i.e., improve the individual functioning. The International Classification of Functioning Disability and Health (ICF) developed by the World Health Organization (WHO), defines functionality as the result of complex interaction between health conditions and contextual factors, including environmental factors. Because AAL products and services intent to change the personal environment surrounding in an "invisible way", in order to improve users participation, they should be considered as environmental factors in an ICF approach. The ICF designates environmental factors as the physical, social and attitudinal environment where people live and conduct their lives [8].

In ICF, an environmental factor is classified as a facilitator if contributes to increase users performance and participation. On the other hand, if an environmental factor restricts users' performance and participation, then it is classified as a barrier. Thus, different environments may have a distinct impact on the same individual with a particular health condition. Therefore, if the individual is surrounded with services and products tailored to his characteristics, he will be able to reach a higher level of functionality. Accordingly, the ICF may arise as a conceptual model for the holistic development of a methodology to evaluate environmental factors and, consequently, AAL products and services.

The existence of a conceptual framework based on standard concepts provides a common language between designers, technicians, stakeholders, service providers and users [9]. Using the ICF as a framework to develop instruments for the evaluation of AAL services permits the terminology, concepts and coded information to be aggregated with the available information, and also to be used as a comprehensive model to characterize users and their contexts, activities and participation. Therefore, the ICF can be used to specify, develop and characterize AAL products and services, as well as to develop appropriate tools to assess them and their impact on user's daily life [9]. Since the current stage of development/evaluation of AAL products and services is still very technology-oriented and its functionality has not been addressed adequately, we propose to develop assessment tools that address the individuals' functionality, assessing environmental factors according to an ICF approach.

This paper consists of five sections, beyond this introduction: 2) Methodology description: definition of the conceptual validation and prototype test, and considerations about the assessment tools developed; 3) Results: presentation of the results obtained by the application of the prototype phase of the methodology; 4)

Discussion, reflection about the results and the assessment tools developed, based on the ICF; 5) Conclusions: final considerations and presentation of suggestions for future work.

2 Methodology Description

The development of this methodology involves the description of all methodological steps that allow a standardization of procedures that can easily be adapted to different products or services, without making the validity of the methodology unfeasible.

2.1 Phases

The evaluation methodology assumes three phases of reference. The first phase is the conceptual validation, followed by a prototype test, and finally a pilot test. Those phases are not isolated, and they are based on a spiral approach that follows the development progress since the beginning (Fig. 1).

The first phase of evaluation, conceptual validation, aims to determine if an idea of a product or service is sustainable in terms of interface and functions. In prototype test, the second phase of the evaluation, it is intended to collect information regarding the usability and user satisfaction. At this phase there is already a physical implementation of the product or service prototype in order to be tested by users. The prototype test is conducted in a controlled environment. Finally, the third phase of evaluation, pilot test, intends to evaluate, in addition with usability and satisfaction, the meaning that a product or service has on users' lives. For this reason, this last phase of testing differs from the prototype phase in the context where it happens. The product or service should be installed in users' homes and integrated into their daily life routines.

In this paper we focus on the first and second phases of the evaluation methodology, because, so far, our work has focused mainly on these two.
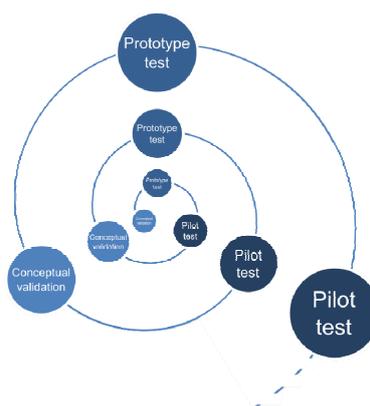
Fig. 1. Phases of reference of the Living Lab methodology.

This methodology is based on the concepts of scene, task and scenario. A scene is the period in which the properties that constitute the context (such as light and noise) are unchanged. Task is the action to be executed and scenario is the context where the scene and tasks take place.

To outline a plan of a generic methodology requires a set of conceptual operations and logistics aspects that needs to be defined for each evaluation phase, including: goals and objectives, evaluation moments, sample selection, instruments and material, facilities, session description and data collection.

The phases of conceptual validation and prototype test are described below.

2.1.1 Phase 1 – Conceptual Validation

The main objective of this phase is to verify the sustainability of an idea regarding the user interface and functions of the product or service. This phase is divided into two subphases: designing the idea and testing with mock ups.

One of the most often used methods to validate/develop an idea is the technique of brainstorming. This technique explores the creative potential of a group. A brainstorming session involves a small group of people (12 participants) who produce a set of ideas in a short period of time [10]. This session should be conduct by a moderator and is composed of four parts: introduction, warm-up, generating ideas, analysis and summary. The main ideas of the session should be listed and registered.

After the idea is validated it is necessary to develop a mock up that allows, trough the techniques of focus group and simulation, to determine the opinions of potential users about the product or service. Mock ups are low fidelity prototypes (not implemented) used to collect preliminary data on the interaction user-system [11]. The mock up test can be done using two methods: focus groups and simulation.

The focus group methodology is a collection of qualitative data that involves a small number of people (6-8 participants) in an informal discussion, focused on a specific subject [12]. This session should be conducted by a moderator and it is composed of five parts: introduction, warm-up, visualization of the mock up, discussion and summary. The main ideas of the session should be listed and registered.

A simulation is an imitation of the functioning of real operations. This technique uses a simulator, considering it as total or partial representation of an object or a task to be repeated [13]. For an adequate evaluation simulation should be used at an early stage of testing, before the service reaches a stable state of development [13]. A simulation session should have eight participants and consists of five parts: introduction, warm-up, testing, filling the questionnaire and summary. The instrument used to collect data is the *conceptual validation assessment questionnaire.* Questionnaires should be analyzed (content analysis) and the results registered and used in a critic review meeting, where the research team decides whether to move on the methodology phases or to repeat conceptual validation.

2.1.2 Phase 2 – Prototype Test

The prototype emerges from the conceptual validation phase, where all functions and

aspects related to the layout of the product or service were attested. The main objective of the prototype testing phase is to evaluate the product or service in terms of usability and satisfaction. Data collection was divided into three evaluation moments: i) pre-test, ii) evaluation during the session test and iii) post-test.

The pre-test prototype is the first of the three evaluation moments that constitute the prototype test and happens immediately before the session of testing. Pre-test session consists of two parts: introduction and filling the *pre-test assessment questionnaire*. Questionnaires should be analyzed (content analysis) and the results registered.

The second evaluation moment occurs during the execution of prototype test itself. It consists of real time and *in loco* evaluation of the interaction between the user and the product or service. This phase consists of three parts: introduction, preparation for the tasks, and execution of scenes. It should be held in the Living Lab that should contain all the necessary equipment related to the product or service that is being evaluated. It should also be equipped with the necessary infrastructures to condition the environment in order to create the different scenes. The data collection is done by observation and registration of field notes. The session is filmed and the video is analyzed using two methods: observation grid filling and register of critical incidents.

The post-test prototype is the last of the three evaluation moments that constitute prototype testing. It consists of filling the *post-test assessment questionnaire* that assesses the usability and satisfaction of users. Questionnaires should be analyzed (content analysis) and the results registered. This material, as well as the registrations from the analysis of the other assessment methods of all moments of evaluation, should be used in a review meeting where the research team decides whether to move on in the methodology phases, to repeat prototype test or to go back to conceptual validation.

2.2 Assessment Tools

The development of the methodology described in the previous subsection resulted in a group of assessment tools. The assessment tools are a very important part of the evaluation and for that reason it's very important to ensure their quality.

Since it was intended to verify if the ICF could be a good framework to evaluate AAL products and services in a Living Lab approach, the research team created the final assessment tool for the different phases, as a result of several brainstorming meetings.

The final assessment tools are: *conceptual validation assessment questionnaire* and *post-test assessment questionnaire* regarding to the first and second phases respec-tively. These tools permit a classification of each component feature of the product or service as a barrier or a facilitator according to the ICF concept. The answer key of the questionnaire was adapted from the first qualifier of the ICF environmental factors. Since the user must take a positive or negative position for each item, the neutral qualifier was removed from the answer key (see example in Figure 2).

1. Rate in relation to the characteristics of layout							
	Barrier			Facilitator			NA
	-3	-2	-1	1	2	3	
· The login was a							
The different components graphic's disposition was a							

Fig. 2. Excerpt of the final assessment tool.

The application of the final assessment tool showed that it enables the rating of component features as facilitators or barriers. The instrument was also able to record what happened during the test session, due to the "not applicable" (NA) option. However, there were difficulties in the response scale, namely the graduation of the barrier/facilitator. For example, in the evaluation of some components, the participants weren't able to identify if a component feature was a small or a medium facilitator.

3 Results from a Case Study

The evaluation methodology described was first used to evaluate the Tele-Rehabilitation service under development in the LUL project [14]. This session presents the prototype test results as an example of the methodology application. In general terms, this service allows supervised remote exercise sessions as a way to maintain health and prevent illness [14]. Table 1 profiles the facilitators and barriers mentioned by the clients and Table 2 those mentioned by the service provider.

Table 1. Aspects mentioned by the clients.

Facilitators	Barriers
Sequence of the session	Self-video image mirrored
Graphic layout of the components	Absence of voice interface
The written information and images	Font size
Touch screen	Closing button too small
Visualization of self-video	Commands not significant
Receptiveness to using this service	Monitoring area display too large
The importance of this kind of services available to older people	Small emphasis on the information provided by the health professionals

Table 2. Aspects mentioned by the service provider.

Facilitators	Barriers
Monitor vital signs at distance	Inability to see the same as clients
Service stable throughout all session	Video window too small
Existence of a repository of available exercises	Inability to zoom client's image Absence of voice interface

4 Discussion

The success of the Living Lab methodology depends on the assessment tools used. In that sense, a major concern with the development of this methodology was to verify the instruments quality, particularly those based on the new ICF conceptual frame. In general terms the results of the TeleReabilitation case study were positive and will be very useful to guide the next phases and further work. Most of the criticisms mentioned by clients and service providers, such as lack of voice interface and the non-adaptation of text size, correspond to aspects that weren't yet functioning due to the very early stage of TeleRehabilitation prototype implementation, but they are a part of the future work planned for the project which is itself a good service specification indicator. When the implementation is complete, it is intended to replicate the prototype test with a larger number of users, integrating the results of this test session and collecting more significant data about usability and satisfaction with TeleReabilitation service.

Although the instrument was not sensitive in recognizing why a particular component or feature acts as a facilitator or barrier, the results seem to point towards a good measure to discriminate facilitators and barriers. Users had difficulty, in the answer key, in gradating the facilitator or the barrier of an environmental factor, and this is one of the major flaws of the instrument. This may happen because this methodology represents an effort to update the concepts behind the development of assessing tools in this particular area. Nevertheless this gradation is required because it is intended to quantify the impact that a certain product or service can induce in users' daily life.

In a Living Lab approach the implementation of ongoing tests to identify the reasons why a product is a barrier is essential, because that's the only way to understand what changes should be made in the product in order to make it more adapted to the user's needs. In other way, it is crucial to understand the facilitator aspects of a product or service particular components in order to define good practices: if a component has a good level of facilitation, then it can be replicated in similar products or services.

5 Conclusions

We proposed ICF as a framework for the development of an evaluation scheme for AAL products and services and we developed an evaluation methodology based on three reference phases (the first two are described in this paper). This methodology was then implemented in a case study – TeleRehabilitation service.

Despite of the operational difficulties in evaluating AAL products and services using ICF conceptual framework, it is still an added value because it focuses the assessment in the user´s functionality. The ICF seems to be useful in a first level of screening, discriminating facilitators and barriers. However, for a more accurate assessment and for the identification of the reasons why an environmental factor is considered facilitator or barrier, it should be associated with other assessment tools.

As future work in LUL and follow up projects (already started) it is suggested to

improve the instrument in order to address the critical aspects identified, including the gradation of the answer key, and to increase the sensibility in recognizing if a particular component or feature acts as a facilitator or a barrier. It's also needed more work to develop new assessment tools that allow the specification of AAL products and services, based on the CIF concept, which would standardize the language between the different stakeholders interested in development of AAL products or services. It is also planned to continue the implementation and testing with this methodology, namely through the pilot test phase and the establishment of a plan of continuous improvement to ensure the quality of the evaluation methodology, in which a set of control mechanisms will be included in order to continually assess the evaluation tools created.

Acknowledgements

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