

# Using MDE to Develop Suitable User Interfaces for Older Adults: A Case Study<sup>†</sup>

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**Abstract:** Software applications have been identified as potentially suitable tools to assist older adults in several aspects of their lives, like healthcare, emotional support and personal security. However, developing usable and useful applications for this population represents an important challenge, given that no systematic solutions have been proposed to support such a process. This article hypothesizes that a model-driven engineering (MDE) approach can help generate suitable user interfaces for elderly people, making the development process repeatable and allowing the systematic reuse of design knowledge about products for these end-users. To determine the validity of such hypothesis, the article presents the results of a case study where a healthcare supporting system for older adults, developed by using an MDE approach, was evaluated in four older adult care centers. The results obtained were highly positive, showing MDE as a possible path to address systematically the development of these applications.

**Keywords:** healthcare mobile application; elderly people; MDE-based development approach; mobile user interface

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## 1. Introduction

Globally, the number of individuals aged 80 years or over is increasing quickly. In the last century, Latin America and the Caribbean have maintained the trend of increased life expectancy by more than 30 years [1]. This brings several challenges to healthcare services, because they have to address the needs for physical and mental health of this population. Computer-based technology has been identified as a potential instrument to address part of this challenge; therefore, several healthcare software applications have been proposed in the past decade to support healthcare activities, like remote monitoring of people with chronic diseases [2], self-report of health problems [3], informal family caregiving [4], and provision of emotional support [5].

Regardless of the effectiveness shown by these applications, researchers and developers identify the design of user interfaces for elderly people as a major challenge, given that most users in this population are digital illiterate or non-native digital users [4,6]. Therefore, they are usually limited to use regular computer-based solutions, and consequently, ad hoc systems should be developed for them to ensure adoption of such technology.

The literature reports several guidelines to design interfaces of software applications for older adults [7,8], but in all of them the developers play a key role, by understanding the guidelines,

adjusting them to the application domain, and implementing them properly in a software application. Although approaches like co-design or participatory design [9] has proven useful for designing special user interfaces, they require experienced designers because a wrong decision is directly translated to the product, jeopardizing its usability or usefulness. In order to reduce this risk, this article hypothesizes that a MDE approach can be used to systematically develop suitable user interfaces for applications that will be used by older adults. Thus, it reduces the leading role that developers have today and the skills required by these people to address the design of such applications.

In a previous work, the authors shown the technical feasibility of developing a telecare system for elderly people by using an MDE approach [3]; however, the suitability of their user interfaces was not evaluated with the target population. To deal with such requirement and, thus, determine the validity of the general hypothesis, this article presents a case study that assesses the suitability of the interfaces of a telecare system. In this evaluation participated 24 elderly people from four care centers located in the Quindío area, Colombia. The obtained results were highly positive showing that the use of an MDE approach would be appropriate to systematically generate suitable user interfaces for software systems that will be used by older adults.

These results are particularly interesting because they were obtained as consequence of using an MDE-based development approach [10], which automatically generates the user interfaces of a system. This approach captures and represents, through 'models', the design knowledge required to conceive user interfaces in a given application domain. These models are processed using 'transformations' that convert conceptual definitions of a system, into a set of navigable user interfaces that can be evaluated by the end-users utilizing a computer device. Thereby, this approach can systematize the development of user interfaces for several application domains, reducing thus the number of design decisions that should be made by developers [11], and mitigating several project risks. Moreover, MDE has proven to be a valuable strategy to reuse design knowledge in particular application domains [12], opening several opportunities to develop suitable applications for older adults.

Next section presents the related work. Section 3 introduces the telecare system to be evaluated. Section 4 describes the case study and Section 5 presents the obtained results and the hypotheses validation. Section 6 discusses the threats to validity related to the case study results. Section 7 presents the conclusions and further work.

## 2. Related Work

Technology, specifically software applications have the potential to improve the quality of life of elderly people, for instance, supporting them in daily activities and providing them health care. However, according to the MATH model [13,14] elderly people do not adopt technology because of the insecurity regarding to its use, lack of a perceived benefit, and the complexity of user interfaces. In many cases, this latter design aspect of the systems does not meet with the requirements or capabilities of this population [15,16]. Consequently, the suitability of these applications depends on the skills of the developers, making the project results unpredictable.

The model driven engineering (MDE) approach was proposed to deal with limitations like this one, but with the potential to be applied to many application domains [10]. Several positive experiences have been reported by the literature in this sense [11,12,17], however few works apply MDE in the development of software applications for older adults. In this sense, most proposals use MDE to develop software that supports remote monitoring or ambient assisted living, but where the solution is not directly controlled by these people; i.e., the older adults are not active users of those solutions, therefore adoption of this technology by the elderly is not an issue for the developers. Examples of these applications are reported in [18–20]. Although useful, these proposals do not address the design challenge stated in this article.

On the one hand, there are proposals that address part of the development process, or a particular phase of it. For instance, Koshima et al. [21] shows the use of a MDE framework for handling high-level specifications that capture the concerns of elderly people still living at home. This

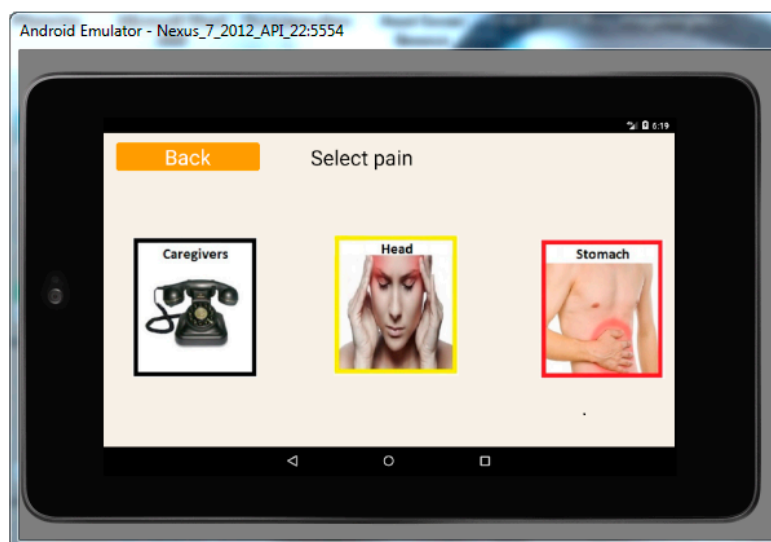
proposal supports only the analysis and partially the design phase of these software systems. Similarly, Mahmud et al. [22] present an approach to address only the structural design of these systems.

Other approaches coming from the design of socio-technical systems can also be used to conceive the user interfaces for older adults, and thus try to ensure usability and usefulness of these systems. In this sense, the most accepted approach is participatory design in which the technical team conduct co-design, mainly on the user interfaces of the system, jointly with the end-users [23]. Although this approach has shown to be useful until today [24], it has several criticisms; for instance, only experienced users can design [25], projects become very difficult to estimate and manage [25], the project manager can lose the capacity to effectively lead the development process [26], the stakeholders have too much influence in making decisions about the product [23,26,27], and the design process becomes slow and costly [26].

Trying to conduct a systematic generation of user interfaces for these systems, the proposed MDE approach considers the modelling of specific features of these interfaces, and based on these models, it automatically generates a navigable Android application that can be evaluated by the elderly. This eases the development of these solutions through rapid prototyping of their user interfaces. Thus, the usability and usefulness of the system can be implemented and adjusted incrementally, using short prototyping-evaluation rounds of one or two days long. Next sections briefly describes the telecare system, and then we present the details of the case study used to evaluate such an application.

### 3. The Telecare System

The telecare system was proposed as a mobile application that runs in a tablet PC and is used by older adults who are novice or illiterate in the use of this technology (Figure 1). This system includes design considerations to facilitate its adoption and appropriation by the elderly, and therefore it includes a visual interface according to its target users and their context. The use of this application requires a prior configuration process, where typically an assistant (e.g., a digital native) records the new users in the system including their names and pictures. The assistant also records the interests and services requested by each users.



**Figure 1.** Screenshot of the Telecare system generated from the models.

The login into the system is conducted by the older adults by touching (i.e., selecting) their picture on the system screen. Then, the main user interface (for pain reporting) is displayed, which allows the older adults reporting several pains they are feeling (Figure 1). Such a report is done by choosing the particular disease represented with icons on a carousel. Using the same interface the

users can also call to a caregiver. The successful delivery of a report provide a feedback indicating “you will be assisted very soon”.

Telecare system has also other two modules additional to the disease report. The first one allows the users to exchange personalized messages with relatives and friends through email, where the complexity of managing these messages is hidden behind a simple user interface that is understandable for older adults. The second module offers the possibility of receiving information or news about topics of their interest, like sports, politics or show business.

A model-driven engineering approach was used to automatically generate the user interface of this application. The MDE approach allowed the authors to manage caring concepts and transform them into concrete software, as well as conducting rapid development and validation of the system prototypes. The models used as input to generate this system were the following:

- *UI models*. These artifacts model user interfaces and their associated widgets (i.e., interactive elements embedded in the UI).
- *Interaction models*. These constructs specify all the tasks the software will perform, including user and system tasks. They were represented using a Concurrent Task Trees (CTT) structure [28].
- *Navigation models*. These models establish the structure of navigation for the UIs considered in the system, which is based on state machines.
- *Domain models*. These models specify the data to support the persistence and integrity of the information associated to the project.
- *Dialog models*. These communication constructs indicate the order in which tasks will be performed, as well as the interaction among users and the UIs.

The use of this MDE approach requires to model and specify the usage scenarios of the telecare application. These scenarios are represented as models that consider functional and interactive features identified by designers during the interviews with the older adults; similar to what happens in participatory design. Examples of predefined scenarios for the telecare system include the login for elderly people, news lists, notifications of pain, and delivery of messages to caregivers. The models of the predefined scenarios help reduce the effort to develop and personalize future applications, since several preferences of older adults have already been captured and represented through these models; therefore, it becomes information that is easy to reuse.

This MDE approach is supported by an Eclipse-based tool that allows the system models to be specified in a simple way (Figure 2). The tool generates a navigable Android application from those models, making automatic transformations from models to code, and obtaining a software prototype able to run on a tablet PC. Therefore, the software developers only have to specify the initial models, and then the tool is in charge of generating the prototype of the system. Regardless the benefits in development time and cost that this approach gives to developers, the most valuable aspects are the following: (1) the result of this process does not depend on the developers' skills and (2) the output is consistent even if the developer runs the application generation process more than once. This makes these developments repeatable, and improvable consistently based on the previous results.

Figure 2 shows the structure and relationship of the models used as input to generate the mobile application. The models structures were represented through a Concurrent-Task Tree diagram and shown in the Eclipse modeling framework.

#### 4. Case Study Description

The case study was designed to determine the usability and usefulness of the Telecare system, which was developed using an MDE approach and with almost no intervention of software engineers on the design of the user interfaces. The evaluation was focused on the usability and perceived value of its user interface according to the end-users opinion. Based on the experimental results, it is possible to determine the level of appropriation experienced by the elderly people. The following section briefly describes the main aspect of this case study.

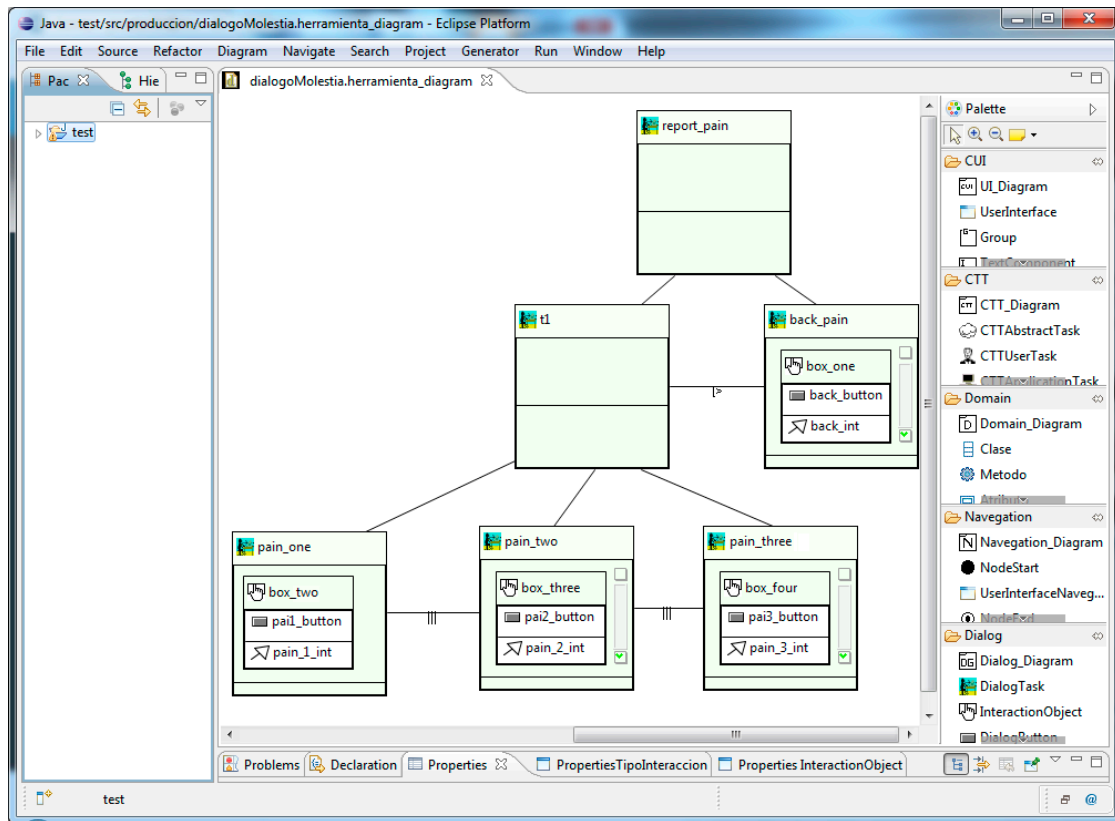


Figure 2. CTT diagram used as input for the Telecare application.

#### 4.1. Goals and Hypotheses

Through this case study the authors want to determine the acceptance level of a mobile application, generated using a MDE approach, by elderly people with few or no experience using this technology. Due to the characteristics of the end-user, usability and accessibility become mandatory requirements.

By using the template that helps define the goals in experimentation processes, reported in [29], we established the following main goal for this case study: to determine the level of usage autonomy experienced by older adults, when using the prototypes generated using the MDE approach. The following specific hypotheses were defined for the experiment:

*H<sub>0</sub>*. In this caregiving scenario, an elderly is not capable to interact with or use autonomously the telecare system.

*H<sub>a</sub>*. An older adult is capable of using and interacting autonomously with the telecare system.

The independent variable of the experiment is the capability of the elderly to autonomously use the system prototype generated using the MDE approach. Several dependent variables were obtained from the user interaction with the application (Table 2), which considered the time spent by each user in completing a task, and also the answers to questions performed at the beginning and end of each experiment.

#### 4.2. Hypotheses Evaluation process

The focus of the test was to analyze *H<sub>0</sub>* and *H<sub>a</sub>* in a binomial distribution, starting from a discrete probability in which only two possible results exist for each task, and their probabilities (P) remain equal throughout the tests, with a fixed success probability occurrence among those tests [30]. The experiment presents the following characteristics of a binomial distribution: (1) only two results are possible, the result of each experiment must admit only two categories (named success and failure),

(2) the tests are statistically independent, and (3) the probabilities of both possibilities must be constant in all the experiments.

**Table 2.** Dependent variables identified in the experiment.

Item	Answer
Have you used computer technology before?	Yes/No
Do you understand the meaning of the icons in the user interface?	Yes/No
Do you understand the text mgs shown by the application?	Yes/No
Task 1 was successfully finished?	Yes/No
Time elapsed to perform task 1	[0 s ...)
Task 2 was successfully finished?	Yes/No
Time elapsed to perform task 2	[0 s ...)
Task 3 was successfully finished?	Yes/No
Time elapsed to perform task 3	[0 s ...)

This analysis assumed  $p = 0.5$  and  $p\text{-value} = 0.05$ . The null hypothesis is accepted when  $p \leq 0.5$ ; on the contrary, it is rejected when  $p > 0.5$ . Assuming that an elderly is able to interact autonomously with the prototype, we evaluated  $H_0$  and  $H_a$  with  $X \sim B(n, p)$  and  $p(X \geq x)$ . In addition, as a rule for the experiment, the level of significance was established as 0.05, which means that the probability of observing differences in random data is only 5%. Each distribution has its dependent variables and the mechanisms to calculate them. The variable  $x$  indicates the number of tasks successfully finished by the user.

#### 4.3. Participants Selection and Description

The participants in the experiment were inhabitants from protection centers located four towns from the Quindío area in Colombia: Salento, Filandia, Circasia, and Buenavista. The centers are mixed entities, with private non-profit and government participation, and similar between them in terms of size, infrastructure and quality of the service they provide. They accept in-patient and out-patient elderly population, where the former are people that are fed and cared for during the day, and return to their homes at the night. The in-patient population are older adults that live inside these centers.

Most of the elderly from these centers were evaluated to determine the feasibility and convenience to include them in the experiment. In order to do that, two nurses in each protection center assessed the physical and mental disability of each elderly, using a scale proposed by the Red Cross [31]. The scale ranges from 0 to 5, being 5 the maximum degree of impairment. After evaluating the candidates, a meeting was arranged with the nurses and a gerontologist to determine the selection criteria of the elderly people to fit with the experiment purpose. These professionals recommended to include elderlies with scores between 0 and 2; which resulted in the four samples (once per center).

The selected people were mainly farmers aged from 58 to 90 (76.9 in average), having hypertension as their main illness. They were also affected by diverse comorbidities, like arthritis, asthma, diabetes, depression, and chronic pulmonary disease that decreased their quality of life and social wellbeing. These people were characterized mainly by humility and generosity. Most of them (75%) not only worked in the fields but also lived in rural areas most of their lives, therefore, they had little or no interaction with computer technology. Next we present the details of these samples and also the evaluation sessions conducted with them.

- *Session 1:* “St. Vincent de Paul home” protection center, in Circasia town, participated 7 men and 2 women. Session conducted on 28 March 2018.
- *Session 2:* “Infant Jesus of Prague home for the elderly” protection center, in Salento town, participated 3 men and 1 woman. Session conducted on 7 April 2018.
- *Session 3:* “Sacred Family welfare center for the elderly” protection center, in Filandia town, participated 4 men and 1 woman. Session conducted on 8 April 2018.
- *Session 4:* “Tarapacá grandparents welfare center” protection center, in Pijao town, participated 5 men and 1 woman. Session conducted on 14 April 2018.

The evaluation sessions were in charge of an expert, who set up the application according to the user's needs and provided training to the participants. Moreover, an observer was present in the sessions to record findings and comments related to the interactions between the users and the prototype. During the exercise, the users received support from a nurse (caregiver) regarding any question or doubt with respect to the use of the system. All nurses were digital immigrants, but experienced in the use of computer systems.

The material used in the experiment included a tablet PC for each elderly, the telecare system, and a training session to teach the older adults how to use the system. The older adults participating in this experiment were informed about the goals of this experience and that their participation was voluntary and no duties were involved on it. Moreover, they signed an informed consent agreeing to participate in this experience.

#### 4.4. Dynamics of the Evaluation Process

After concluding the setting and the training processes, the users had 5 to 10 min to explore the system by themselves. Then, they had to perform the following tasks using the system:

- *Task 1: Reporting an illness. The user had to send a notification indicating a particular pain assigned to them.*
- *Task 2: Reading a news story. The user had to select a news story from a set shown by the system, and read the first two sentences.*
- *Task 3: Sending a message to a relative or friend. The user had to select a contact from a set (shown in a pictures carousel) and send a personalized message to him/her.*

A maximum of three tries were defined to complete each task. The application recorded a log file in background, indicating the action performed by the user and the corresponding timestamp. This information was then used to understand the actions and compute the time spent in performing each task. After the experiment each older adult was interviewed to obtain personal feeling about the usability and usefulness of the system, and also to determine the pertinence of their participation in the case study.

## 5. Case Study Results

The exercise was conducted by 24 older adults that complied with the inclusion criteria. By assuming that the three tasks assigned to the participants were similar in terms of complexity and time demand, we built the binomial distribution with the time spent by the participants in accomplishing the three tasks. Thus, we determined the significance of the obtained results.

Figure 6 shows the binomial distribution, indicating a significance value of 0.03196; a value that is lower than 0.05, that is the maximum error established in Section 4.2 and a regular value to determine validity according to the literature. The percentage of success was 70.8% (17 out of 24 participants completed successfully the three activities), therefore the null hypothesis was rejected, leaving the alternative hypothesis as valid; i.e., "an older adult is capable of using and interacting autonomously with the telecare system". In Figure 6, X indicates the number of people who successfully performed the three tasks; i.e., it assumes the value of 17.

The experiment was set out to obtain the time spent by the adults to perform each task; this data was obtained as a metric to know what difficulty was encountered by the user when utilizing each functionality of the system. The results achieved for each metric are favorable, showing low response times considering the users' characteristics.

The participant with the lowest time spent 6.4 s on selecting a news story (task 2) and the adult who took the longest time spent 27.3 s in reporting an illness (task 1). The standard deviation was around 30% of the average value of the time spent in each task. This is an acceptable dispersion considering the features of the participants.

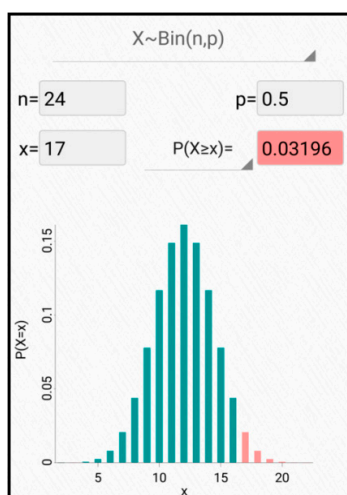


Figure 6. Binomial distribution of the times spent by the participants.

Table 3 shows the results obtained in the four protection centers. The columns with an “--” indicate that the person was not able to complete the task. With the exception of task 2 in the first experimental session, the results from every center are consistent among them.

Table 3. Summary of the obtained results.

	Particip. #	Age	Have You Used Techn. Before?	Understand the Meaning of the Icons?	Understand the Text Msg?	Time Task 1	Time Task 2	Time Task 3
Session 1	1	82	No	Yes	Yes	22.0 s	27.2 s	10.2 s
	2	85	No	No	Yes	18.2 s	26.9 s	15.1 s
	3	84	No	Yes	Yes	14.7 s	26.4 s	20.1 s
	4	71	No	Yes	Yes	8.8 s	10.2 s	14.5 s
	5	58	No	Yes	Yes	6.5 s	14.0 s	6.4 s
	6	82	No	Yes	Yes	11.3 s	21.2 s	12.0 s
	7	82	Yes	No	No	15.3 s	25.8 s	10.4 s
	8	65	No	Yes	Yes	14.2 s	24.8 s	6.9 s
	Average:	76.5				14.2 s	22.0 s	11.9 s
Session 2	10	79	No	No	No	--	--	19.2 s
	11	78	No	No	Yes	17.7 s	10.0 s	12.2 s
	12	90	No	No	Yes	10.8 s	--	18.0 s
	13	74	Yes	Yes	Yes	12.6 s	16.9 s	10.8 s
	Average:	80.2				13.7 s	13.4 s	15.0 s
Session 3	14	71	No	Yes	Yes	15.4 s	10.3 s	15.1 s
	15	59	No	Yes	Yes	20.2 s	18.0 s	11.2 s
	16	79	No	No	Yes	10.4 s	14.7 s	15.0 s
	17	75	No	Yes	Yes	11.2 s	13.9 s	11.1 s
	18	76	No	No	No	--	--	--
	Average:	72				14.3 s	14.2 s	13.1 s
Session 4	19	82	No	Yes	Yes	11.9 s	16.3 s	18.0 s
	20	73	No	Yes	Yes	8.2 s	21.9 s	13.7 s
	21	76	No	Yes	No	22.8 s	--	--
	22	90	No	No	No	--	--	--
	23	80	No	Yes	Yes	27.3 s	14.1 s	13.4 s
	24	72	No	No	Yes	--	--	9.6 s
	Average:	78.8				17.5 s	17.4 s	13.6 s
	<b>Average:</b>	<b>76.8</b>				<b>14.8 s</b>	<b>18.3 s</b>	<b>13.1 s</b>
	<b>Std. dev.:</b>	<b>8.0</b>				<b>5.2 s</b>	<b>6.0 s</b>	<b>3.8 s</b>



Table 4 presents the values of the dependent variables involved in the stated hypotheses. On the one hand, there is evidence of the influence of the identification of the whole text in the application (i.e., one of the dependent variables), which principally involves tasks 2 and 3; i.e., reading a news story and sending a message. The older adults who received a *No* in this variable, influenced their performance in both mentioned tasks. On the other hand, individuals who had a *No*, as response in identifying all the icons (i.e., other of the dependent variables), had greater difficulty in performing the task 1; i.e., to report an illness.

The number of elderly who experienced technology for the first time during this experience was important (22 out of 24 people). This feature was envisioned before conducting the case study, therefore the MDE approach used to generate the system prototype emphasized the simplicity of the user interfaces and the interaction between the older adults and the system. This allowed that people, even with some physical limitations, were able to use the application.

**Table 4.** Values of the dependent variables.

Dependent variables	Value
Number of individuals who responded have not interacted with technology	22
Number of individuals who understood all icons of the application	15
Number of individuals who understood the text shown by the application	18
Percentage of individuals who successfully performed task 1 (reporting an illness)	83.3%
Average time spent in task 1	14.8 s
Percentage of individuals who successfully performed task 2 (reading a news story)	70.8%
Average time spent in task 2	18.3 s
Percentage of individuals who successfully performed task 3 (sending a message)	83.3%
Average time spent in task 3	13.1 s

According to the standard deviations shown in Table 3, a homogenous set was obtained for each task. It may also be deduced that the average was positive for each exercise, considering that the participants were people with little or no previous experience using computing technology. Finally, 79% of the assigned tasks were successfully completed, and they involved the 70% of the participants. This is a significant number in the design of interacting system considering the literature of this area.

In the interviews conducted to the participants after each evaluation session most of them mentioned to feel comfortable using the prototype, and consider the system valuable to support their daily life activities. Various asked for the feasibility of using the prototype daily at their protection centers, and some of them indicated to be able to buy a tablet PC for using the application.

## 6. Threat to Validity

This validity is related to the veracity of the reported results. Any factor interfering with the significant interpretation of the evaluation results represents a threat to the validity [32]. Within the context of this research, parameters were considered to respect the experimental protocol and—in turn—provide representativeness to the data collected. Table 5 shows the threats to validity identified in this case study and presents the way in which each one was addressed.

**Table 5.** Analysis of threats to the validity of the experiment.

Categ.	Threat	How Was the Empirical Validation Addressed?
<b>Conclusion</b>	Low statistical power	The importance of the results is critical due to the need to demonstrate the stated hypothesis system. Statistical evidence was respected by following strict protocols to apply the analysis of the results, seeking relations, conclusions, attributes, and dependence of data.
	Assumptions violated by statistical tests	Statistical assumptions were kept in the hypothesis test, carrying out a binomial distribution.
	Error rate	The significance value was established from a review of the literature on regular configurations for experiments similar to the one reported in this paper (< 0.05). This represents 95% of certainty that the association we are studying is not random.
	Reliability of the measurements	The values assumed by the observed variables were established by a tracking system that run in background during the experiments and that recorded a detailed log file for each participant. A cross-checking process with the observer participating in each session, and also with the information stored in the log file, was done after the experiment to determine the reliability of the main results.
	Random irrelevance in experimental fit	No elements arose outside the experimental environment in the sessions of this experiment.
	Random heterogeneity of assignments	To guarantee participant heterogeneity in this evaluation process, the study involved a sample of adults from four social protection centers. The inclusion of these people was decided after applying them a standard physical and mental disability test proposed by the Red Cross [31].
<b>Internal</b>	History	Participants worked only once in the experiment, therefore, there was no influence related to the history. Moreover, no effects were reported due to the execution of the validation at different time periods.
	Maturation	Due to considerations of environment, participants profile, and selection criteria, we selected the samples that changed in similar manner during the experiment.
	Instrumentation	A stable and reliable prototype was developed through conceptual models. The system was adequate for the hypotheses validation and avoided us shortcomings with the users during the evaluation process.
	Statistical regression	Participants were selected based on the results of an evaluation where a regular instrument proposed by the Red Cross was used. No additional classification tasks were applied to the participants.
	Selection	Equivalent groups were required, considering the inclusion criteria reported in Section 4.3.
	Mortality	Participants were free to abandon the experiment at any moment. However, this never happened during the experiment.
<b>Construct</b>	Inadequate preoperational explanation of constructions	To avoid lack of clarity in both the assigned tasks to the users and the functionalities of the prototype, personalized training was conducted with each elderly adult before the experiment.
	Mono-method partiality	Multiple complementary measures were used to assess the autonomous capacity of older adults to use the prototype. Several observations resulting from the participants suggested subjective interpretation, and they were measured according to the theoretical expectation of the researchers.
	Guessing hypothesis	The experiment suffers from this threat, which was reduced by not discussing about the research questions.
	Restricted generalizability through constructions	Considering the simplicity of the evaluation scenario, experimental results have high probability to be generalizable to other scenarios with similar characteristics.
	Experimenter expectations	The researchers had expectations on the possible applicability and use of prototypes generated using the MDE approach. However, any attempt to influence the opinions or behavior of the participants was avoided.
<b>External</b>	Interaction of selection and treatment	The sample of participants chosen for the experiment was objectively selected using a clear inclusion criteria. Moreover, the size of the sample seems to be large enough to determine suitability of the system for older adults with characteristics similar to the participants (i.e., farmers and elderlies living in rural areas). The population characteristics showed no signs of a possible influence on the results.
	Interaction of the environment and treatment	Researchers were especially careful in using an adequate and representative language to instruct the participants about how to use the prototype. No direct explanations were given to the users to help them perform the assigned tasks.

## 7. Conclusions and Future Work

This research work explored the feasibility to use a model-driven engineering approach to generate software systems that can be suitable for older adults, at least in terms of usability. This proposal tries to deal with the ad hoc design of these applications that today depends mainly on the capabilities of the system designers [7,8] and follows an artistic instead of a systematic process [9].

In order to do that, a telecare system for older adults was automatically generated using a MDE approach. The usability of the system was evaluated into four protection centers for elderly people of Quindío area, in Colombia. In such an experience participated 24 older adults, selected after applying them a standard instrument to assess their physical and mental disability.

As a result of the hypotheses evaluation process, most participants (70%) shown to be able to complete the assigned task using the system prototype. Moreover, they understood how to access to the services provided by the system through the user interface and how to navigate these interfaces. The strategy proposed by the MDE approach to implement the interaction between the user and the system also shown to be suitable for the elderly allowing the latter to use autonomously the telecare application.

On the other hand, the use of models with relevant properties for older adults during the prototyping stage, evidenced an important benefit in terms of central artifacts for design decision-making and code generation activities. It also allows the reuse of the design knowledge encapsulated in those models, easing the development of other applications for the same target population. The user-centered methodology, used to create the models that then allowed obtaining the prototype, affected positively the suitability of the resulting system.

The next step in this research initiative is to develop new software systems for older adults, but to support activities in other application domains; e.g., entertainment or promotion of healthy life. The evaluation results of the new systems will allow us to determine, with more evidence, the feasibility of using MDE approaches to develop suitable software systems for older adults.

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