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Identification of UX dimensions for incident reporting systems with mobile applications in urban contexts: a longitudinal study

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Abstract Incident reporting systems enable end-users to report problems that they have experienced in their working activities to authorities. Such applications are sought to sense the quality of the environment, thus enabling authorities to promote safety and well-being among citizens. Many governments are now promoting the use of mobile applications allowing citizens to report incidents in their neighbourhood to the administration. Nonetheless, it is not clear which user experience dimensions affect the adoption of incident reporting systems, and to what extent anticipated use of the system (anticipated UX) is a determinant for predicting the user experience with the final application. In order to understand how citizens perceive incident reporting systems and which factors affect the user experience (UX), we have performed empirical studies including interviews in early phases of the development process and empirical user testing of advanced prototypes. In this paper, we present the results of a longitudinal study on the evolution of the perception of UX dimensions along the development process, from interviews to running prototypes. Hereafter, we describe the method that has been used for coding the findings of these empirical studies according to six UX dimensions (including *visual and aesthetic experience*, *emotions*, *stimulation*, *identification*, *meaning & value* and *social relatedness/co-experience*). Moreover, we describe how the findings have been associated with users' tasks. The findings from interviews and

user testing indicate that whilst the perceived importance of some UX dimensions (such as *identification* and *meaning & value*) remains similar over time, other dimensions such as *stimulation* and *emotions* do evolve. Beyond the practical implications of this study for the design of incident reporting systems, this work presents an approach that allows comparing the results of UX assessments in different phases of the process.

Keywords Incident reporting systems · Interviews · User testing · Empirical studies · User experience · Mobile applications · Government

1 Introduction

After the pioneer work by the state of Virginia (USA) (Goodchild 2007), many administrations throughout the world started deploying mobile application for providing citizens with information of public interest (e.g. weather forecasts, election monitoring, tourist information, traffic) (Moon 2004). The willingness (and need) of direct and on-site citizen involvement is often highlighted during natural disasters and massive accidents (Moles and Rohmer 1978). Nonetheless, citizens might also be interested in reporting urban incidents (e.g. broken street lamps, water leakages) that affect the quality of life in the neighbourhood.

Urban life differs from other aspects of human life and has many kinds of spatial and physical circumstances that pose challenges for interaction designers (Bradley and Lang 1994; Fischer and Hornecker 2011). Today, it is well known that the acceptance of m-government services¹ is

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¹ M-government refers to the use of mobile technology for improving the communication between citizens and the government.

directly related to the ability to address the citizens' needs (Proshansky et al. 1983); and for that, usability and user interface design are key issues (Väänänen-Vainio-Mattila 2008). Nonetheless, little is known about how citizens perceive incident reporting systems and which user experience (UX) dimensions can be used as triggers for motivating users to use such applications. Moreover, even less is known about whether (or not) user experience affects citizens' opinions about the overall quality of the services provided by the local administration. Therefore, clear understanding of these questions is required to promote citizens as real sensors of their environment and increase their participation in m-government initiatives (Goodchild 2007).

The main goal of this work is to investigate which UX dimensions contribute to the overall user experience in the domain of incident reporting with mobile phone applications. This research was conducted within the project FEDER Ubiloop whose ultimate goal was to investigate the development of incident reporting systems and their potential social impact in metropolitan area of Toulouse, France. Our working scenario is illustrated by Fig. 1 that presents how citizens might use diverse types of devices (mainly mobile phones) to report incidents such as potholes, missing road signs, graffiti, broken furniture in parks and hornets. Ubiloop is proposed as a self-service system for mediating the communication between citizens and the administration. It presumes that incidents reported by citizens will prompt the city administration to solve those problems that are perceived as affecting the residents'

quality of life in the city. On one hand, the citizens are empowered with a system that will help them to autonomously perform an incident report, thus reducing bureaucracy. On the other hand, the city administration can have access to data provided by citizens, thus improving the detection of problems that would be difficult to identify otherwise.

Nonetheless, it has been reported that the perception of UX dimensions might evolve overtime (Hassenzahl and Tractinsky 2006). In order to better understand how users report UX along the development process, we have conducted empirical studies in two points in time: in early phases using *semi-structured interviews* and in later phases of the development process by conducting user testing of an advanced system prototype using *think aloud protocols*, three standard questionnaires and *semi-structured post-interviews*. The study focuses on six UX dimensions (including *visual and aesthetic experience, emotions, stimulation, identification, meaning & value* and *social relatedness/co-experience*). In order to compare results found in early and late phases of development processes using diverse methods, we anchored the findings in a task model that describes the tasks citizens have to perform when reporting incidents using a mobile application.

The paper is organized as follows: Sect. 2 presents a definition of UX dimensions that are addressed in this paper and methods for assessing UX. Section 3 describes the methodology used in the longitudinal study, and in particular, it presents the steps followed to compare the results of the development process obtained in different points in time. Section 4 describes the two series of interviews (*semi-structured requirement interviews* and *scenario-based interviews*) employed in early phases of the development process where no prototype was yet available for testing. Section 5 describes the empirical study involving twenty users engaged in reporting urban incidents using the Ubiloop application. Section 6 presents the main findings of both studies and compares the results. The main results are discussed in Sect. 7 which show how our findings can be used to better understand incident reporting systems for improving the communication between citizens and the administration. Moreover, we discuss the implications of the methods used in this longitudinal study and to what extent UX dimensions could be collected in early versus advanced phases of the development process. Lastly, the paper presents conclusions and future work.



Fig. 1 Overview of incident reporting: users report incidents like potholes, graffiti, obstacles or broken street lamps to the local government using mobile phone applications

2 State of the art

The concept of UX goes beyond usability, encompassing cognitive, socio-cognitive and affective aspects of the users' experience with artefacts. UX is commonly

understood as being subjective, dynamic and context-dependent (Law et al. 2009; Law 2011). It is still controversial if user experience is measurable (Hassenzahl and Tractinsky 2006). This work is following the pragmatic approach that it is possible to measure a set of dimensions that contribute to the overall user experience. What is important to note is that user experience and usability are independent dimensions: a limited usability does not automatically lead to a bad user experience and the cumulative user experience can be a positive one; similarly, good usability does not necessarily lead to a positive overall user experience. This can be easily seen in games where aspects of usability, like e.g. task performance, do not necessarily imply a positive user experience with the game. Thus, before starting to design and develop a system, it is important to understand how people perceive and act on the environment and how user experience (UX) dimensions can affect the system's acceptance and its usage. For that reason, we hereafter present an overview of the UX dimensions and UX evaluation methods that we consider relevant for the development of incident reporting systems.

2.1 User experience dimensions

The literature in human-computer interaction (HCI) describes a broad variety of dimensions that are associated with user experience. The six most commonly described UX dimensions in the HCI literature include:

- *Visual and aesthetic experience* refers to the pleasure from sensory perceptions; how beautiful something is perceived (Hassenzahl 2002). It covers beauty (Hekkert 2006) and classic aesthetic characteristics as clarity and symmetry (Lavie and Tractinsky 2004). It is also about how aesthetically pleasing and satisfying an interaction is (Alben 1996). It has been shown that system attractiveness and aesthetics do have a strong influence on the perceived usability of a system (Hassenzahl 2003; Quinn and Tran 2010).
- *Emotion* has been identified as a key factor of UX (Hassenzahl and Tractinsky 2006). The emotional experience is one of the main factors contributing to product experience, including feelings and elicited emotions (Desmet and Hekkert 2007). Emotions are also considered important parts of the user's experience before, during and after interacting with an interactive system (Mahlke and Lindgaard 2007; Mahlke and Thüring 2007).
- *Stimulation* is described as a hedonic attribute of a product, which can lead to new impressions, opportunities and insights (Hassenzahl 2008). Sheldon et al. (2001) state the need for pleasurable stimulation to

encapsulate the single most basic motive according to hedonistic philosophies. Hedonic experiences are also known under the term *innovativeness* to describe the ability of a product to excite the user through its novelty (Jääskö and Mattelmäki 2003) and innovativeness (Karapanos et al. 2010).

- *Identification* addresses the human need to express one's self through objects (Hassenzahl and Tractinsky 2006). This self-presentational function of products is entirely social; individuals want to be seen in specific ways by relevant others. Thus, using or owning a specific product is a way to reach a desired self-presentation. Identification can be seen as self-expression through an object to communicate identity. User personality is part of user experience in socio-cultural contexts, including self-image, attitudes, values, life-style and previous experiences (Jääskö and Mattelmäki 2003).
- *Meaning and value* refers to "Ideo pleasure" (Jordan 2000), values the product can satisfy. This means that products are sometimes chosen because they reflect or represent values that are important to the person. It covers two aspects of meaning: the experience of meaning and the meaning attached to a product (Desmet and Hekkert 2007).
- *Social relatedness/co-experience* Hassenzahl (Hassenzahl 2004) includes this dimension into identification. The social aspect of relatedness is addressed by Gaver and Martin (Gaver and Martin 2000) under the term of intimacy, which is used to refer to non-verbal, implicit forms of communication. Jordan (Jordan 2000) describes it as socio-pleasure or something that deals with interaction with others.

User experience with mobile service has been defined as the combination of factors from service experience and user experience (Väänänen-Vainio-Mattila et al. 2008). Service experience is affected by factors such as perishability, intangibility and the self-service nature of the services themselves (Väänänen-Vainio-Mattila et al. 2008). There is a variety of factors that should be taken into account for any type of mobile based services, such as the coherence of the service integration, social navigation and interaction, the ability to dynamically change services, the intangibility of the service and the availability of multiple interaction styles.

Currently, the main mechanisms with which individuals act in their environment are poorly understood in the field of environmental psychology (Väänänen-Vainio-Mattila 2008) and unfamiliar to the HCI domain. Nonetheless, it seems important to know (1) how individuals perceive their environment, (2) how they discover incidents and (3) how they transfer this knowledge to self-service systems.

Two concepts are important to understand how people perceive their environment: place identity and amenity. Place identity (Proshansky et al. 1983) refers to the cognitive aspects related to the perception of the environment, including one's attitudes, feelings, ideas, memories, personal values and preferences towards the whole range and all types of physical settings. These aspects of place identity allow people to understand the environment they live in and their overall experience. In this way, one can consider place identity as a structure of the self-identity, which means situated and self-centred. Thus, the same physical environment can be perceived differently by various individuals. A handrail, for example, can be perceived as a help for elderly people and as an object to play with for kids.

The concept of amenity refers to the ability of spaces to evoke emotional responses such as attractiveness and desirability. Amenity refers to any benefits of a property, especially those that affect attractiveness or value of places. Amenities include restaurants, parks, swimming pools, theatres, children's playgrounds, bicycle paths, and so forth. Amenities also include pleasant architecture, nearby activities, good schools or a low crime rate, all of which add to the desirability of place and property. The concept of amenity explains how environmental qualities can have an impact on the hedonic and social perception of environment. The identification or perception of an incident is related to a mental contradiction between an expected state of the environment (influenced by the place identity of a person and the amenities given in that environment) and the real state of this environment. When this contradiction is too high, people feel the need to report this contradiction or correct it.

For Moles and Rohmer (1978), the main role of the urban environment is to act as a mediator between individuals and the society. Such mediators exist on different levels ranging from a macro to a micro level. At the macro level, the role of the urban environment includes building public transportation or the global management of the city. Individuals typically do not have a lot of influence on the macro level. On the micro level, the urban environment refers to events and objects that individuals interact with in their daily actions, like taking a bus or enjoying a park. The role of a designer of any incident reporting systems is to improve the communication between the individual (individual's daily experiences on the micro level of the urban environment) and the local administration or government (on the macro level of the urban environment).

2.2 Overview of methods for evaluating user experience

The ultimate goal of the UX evaluation is to find out the emotional attachment that users have to a product, system

or service. In the last decades, a variety of methods have been proposed to help to understand and investigate aspects of user experience. It is interesting to notice that users' perceptions might evolve overtime (Hassenzahl and Tractinsky 2006; Law et al. 2009). For that, we have to distinguish methods that are suitable to assess the anticipated use of the system (which typically occurs in early phases of the development process) from those that can effectively measure the users' perceptions and responses after using a functional prototype (which is only possible in late phases of the development process).

User experience evaluation is currently performed using standard usability evaluation methodologies and extending them, e.g. with additional questionnaires, to measure aspects contributing to user experience. Table 1 gives an overview on evaluating user experience, briefly describing their advantages and limitations and how suitable they are for supporting the assessment in early and late phases of the development process. Methods used in early phases can be performed without a functional prototype, which is a basic requirement for methods used in late phases of the development process.

Probes are mainly used to gather insights on the users' context in order to better inform the design process in an early stage (Gaver et al. 1999). Probe packages are provided to the study participants and typically consist of diaries, cameras, postcards, sometimes maps of the explored environments and several other means to obtain as much data as possible from the participants and their context.

The experience sampling method (ESM), originally introduced by Larson and Csikszentmihalyi (Larson and Csikszentmihalyi 1983), asks the user to protocol his feelings and emotions before, during or after the use of a product. Computer-supported forms of the ESM today help to investigate everyday life. ESM is conducted in situ, involves many participants, takes place over time and collects quantitative and qualitative data. When using experience sampling, the specific research interests as well as the measurement methods which are suitable to gain the desired information must be carefully considered. The main qualities of experience sampling are that usability and user experience factors can be studied within a natural setting, in real time, on repeated time occasions, and by request.

The semi-structured interview method combines some structured questions with some unstructured exploration. Semi-structured interviews are often used to collect facts, attitudes and opinions—but when properly designed they can also help to understand the users' goals and gather information about users' tasks, task flow and work artefacts (Wilson 2013). One of the advantages of this method is that it can be used to assess the anticipated use of the systems

Table 1 User experience evaluation methods. (adapted from Bernhaupt 2010)

Evaluation method for UX	Key facts	Advantages	Shortcomings	Phases of development process	
				Early	Late
Ethnographic studies using probing approaches	Qualitative insights on people's daily lives	Gives insights on people's daily lives on a qualitative basis, can be used before a product is developed	Probing material has to be carefully designed	Yes	No
Experience sampling method	Insights on people's daily lives	It can be used throughout the development life cycle	It is time-consuming to analyse; personalization and individualization are difficult to be recorded	Yes	Yes
Interviews	Questions in semi-structured interviews focusing on the collection of qualitative data. Insights on people's daily lives	It can be used before a product is developed to assess users' expectations or after actual use of the product to understand users' perceptions	Questions should be carefully designed to address anticipated use or actual use of the systems	Yes	Yes
AttrakDiff	Questionnaire to evaluate the dimensions of hedonic and pragmatic quality	Easy to use, fast	Typically used after interacting with the product. Measures only short term perspective of one factor that contributes to the user experience	No	Yes
SAM/Emocards	Questionnaire oriented towards self-assessment of emotions	Easy, fast, cheap	Typically used after interacting with the product, so effects like the recency effect can influence the judgment and people might not remember their emotions during the interaction well	No	Yes
Biometrical measurements	Using heart rate, skin conductance or facial expression changes to investigate emotions	Detailed insight on minimal physiological changes	Interpretations of biometrical measurements is still unclear, set-up is expensive and resource intensive	No	Yes

and/or to assess the users' perceptions after the use of the system.

Hedonic quality is evaluated using questionnaires like the AttrakDiff (www.attrakdiff.de) (Hassenzahl 2008). Focusing on emotions as an important part of user experience, various forms of questionnaires have been used.

Emocards (Desmet et al. 2001) uses sixteen faces representing eight emotions on the two dimensions arousal and pleasantness. Other questionnaires measuring emotion have been developed in psychology, e.g. the Self-Assessment-Manikin (SAM) or the use of semantic differentials (Bradley and Lang 1994). In the area of games in particular, emotions have been evaluated using bio-metrical measurements (Mandryk et al. 2006). The experiential perspective dealing with the nature of experience has mainly been investigated from a research perspective (Forlizzi and Battarbee 2004).

3 Methodology

Our methodological approach was designed to identify anticipated user experience for incident reporting systems and compare the findings with episodic user experience when users can report their appraisal for using a fully fledge prototype to report an incident for the first time. Anticipated user experience was assessed in early phases of the development process, and the results were used as starting point for designing the Ubiloop application. In a later phase, when a functional prototype was available, we tested the Ubiloop application with end-users to assess episodic UX. In this section, we provide a view at glance about these methods and how we combine their results.

3.1 Empirical methods employed in the study

Empirical methods with end-users were used both in early and late phases of the development process to understand users' perceptions of individual UX dimensions. In early phases, we aimed at understanding the anticipated use of the system by the users. In later phases, we focused on users' perception of the system after using it. The evaluation in early phases of the development process included *semi-structured interviews* focused on requirements (*semi-structured requirement interviews*) and focused on scenarios (*semi-structured scenario-based interviews*). In later phases, *user testing* of running prototypes were jointly used with *standard questionnaires* and *semi-structured post-interviews*, focusing on the use of the Ubiloop application. The list of methods employed in the study is presented in Table 2.

As we shall see, except for standard questionnaires (i.e. SUS, SAM and AttrakDiff), all the other empirical methods

Table 2 Methods used in the longitudinal study of UX of Ubiloop

Phase of the development process	Evaluation method	Specific goals
Early phase without prototype	<i>Semi-structured requirement interviews</i>	Identify requirements and scenarios of use for the application
	<i>Semi-structured scenario-based interviews</i>	Identify UX dimensions perceived as important by users in predefined scenarios of use
Late phase after using Ubiloop application	<i>Thinking aloud during user testing</i>	Understand users' perception of UX dimensions whilst using the application
	<i>SAM questionnaire</i>	Collect a metric about UX dimensions
	<i>AttrakDiff questionnaire</i>	Collect a metric about UX dimensions
	<i>SUS questionnaire</i>	Collect a metric about usability
	<i>Semi-structured post-interviews</i>	Understand users' perception of UX dimensions after the use of the prototype to perform predefined scenarios of use

used in the study allowed to collect users' comments, either as the result of questions raised during interviews or due to the use of think aloud protocols during the user test sessions of the Ubiloop application. User comments support the identification of two types of information that we consider important in our research: UX dimensions that users considered relevant and scenarios of use for the application. The method used to analyse the user comments and subsequently code them into scenarios of use and UX dimension is presented in Sect. 3.3.

Questionnaires were introduced in the study to collect standard metrics to which we can refer to when we talk about the overall quality of the Ubiloop application. The SUS questionnaire was used in the experimental protocol to give an indicator of the overall usability. A low SUS score would be an indicator to determine whether (or not) the Ubiloop application has usability flaws that would affect the analysis of UX dimensions. The questionnaires SAM and AttrakDiff were used to collect overall metrics about the UX so that we can compare standard UX metrics with the findings obtained from users' comments.

3.2 Model-based task analysis

The impact of UX dimensions might depend on the user's tasks and goals with the system. In order to understand common tasks that users have to accomplish when reporting and incident using mobile technology in urban contexts, we performed a model-based task analysis. A task model was formalized after performing a review of twenty-three existing applications in the domain. The analysis focused on reporter tools and encompassed applications available in 14 different countries worldwide. We have found out that despite the broad diversity of urban incidents that can be reported by those tools (more than 340), it was

possible to identify a task pattern which contains three main tasks and 26 sub-tasks, as illustrated in Table 3.

The tasks described in Table 3 can be combined, allowing the extraction of multiple scenarios. Nonetheless, not all combinations are actually feasible, for example, it should not be possible to *submit an incident* before *detecting* it. In order to represent such temporal and operational constraints, we have built a task model using the HAMSTERS notation (which stands for Human-centered Assessment and Modeling to Support Task Engineering for Resilient Systems) as illustrated in Fig. 2 (see (Martinie et al. 2011) further details about the HAMSTER notation). By simulating the task model, we can extract many different scenarios which can be compared with observation of user tasks with empirical methods. For that, this task model should be considered a central piece of our work for validating the user scenarios reported by users during the *interviews* and *user testing*. Moreover, as we shall see in the next section, this task model provides us a common ground for analysing scenarios reported by users and user experience dimensions.

3.3 Method used for coding findings with respect to UX dimensions and user tasks

In order to allow the comparison of the data in early and late phases of the development processes, we coded users' comments and interpolate the findings using the task model. First of all, all user comments collected during *interviews* and *user testing* were transcribed by a French native speaker to constitute a corpus of text segments. The corpus of text segments was analysed according to the grounded theory approach as described in Glaser and Strauss (1967). Every segment of text was interpreted and coded in classes of meaningful information covering UX

Table 3 Generic task model used as a reference for the domain of incident reporting systems using mobile technology in urban contexts

Tasks for reporting an incident	Sub-tasks
Detect incident	Recognize incident Identify who should solve the incident Decide to report incident
Submit an incident	Describe the incident Locate the incident Inform time of the incident Provide user identification
	Select incident category Rate the incident As potential danger As inconvenience Provide a description By a text By a picture/video Call hot line Provide address Pinpoint on a map Use landmarks Provide GPS coordinates Tell when incident occurred Record when the incident is reported
Follow-up the incident	Subscribe for notification Share reports See someone else's reports

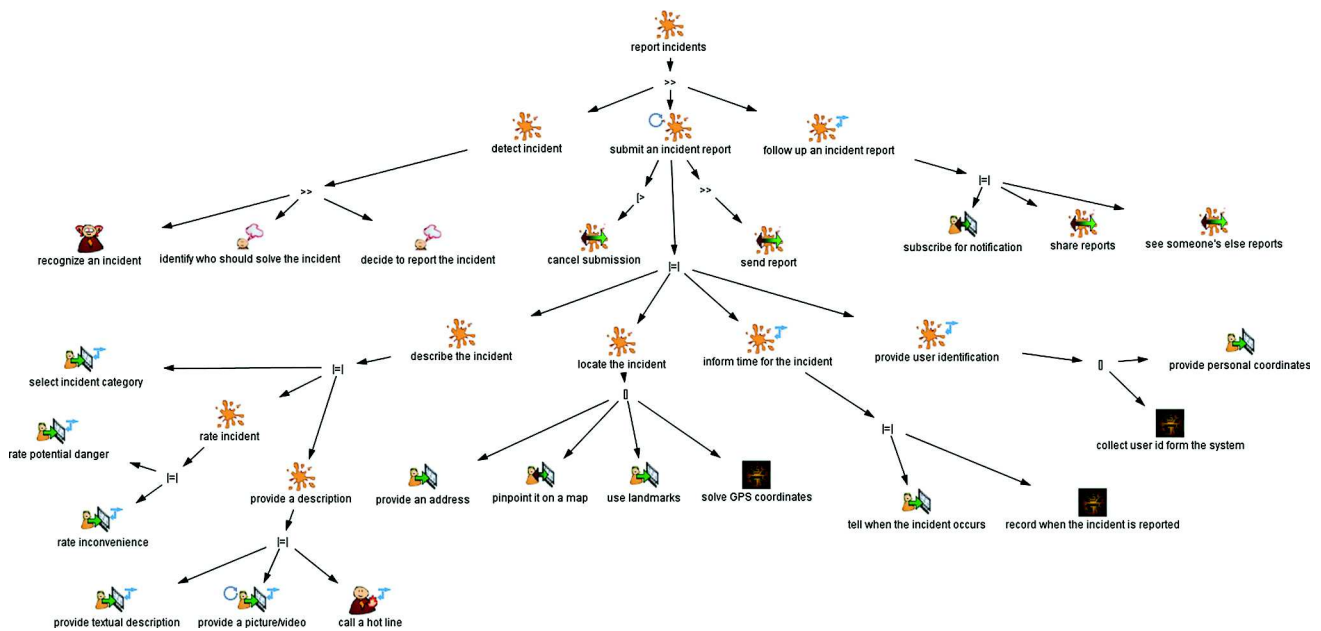


Fig. 2 Generic task model for reporting an incident

dimensions and scenarios for performing user tasks. For coding UX definitions, we used the definitions presented in the state of the art (see Sect. 2.1). For coding scenarios reported by users, we used the reference task model for reporting incidents (see Sect. 3.2). The coding process was

supported by the MaxQDA 10 software (Rossel et al. 2006). To reduce the impact of subjective interpretations, the coding of UX dimensions and scenarios was cross-checked by two independent experts holding a Ph.D. in HCI.

A typical segment of text featuring the visual aesthetic UX dimensions is “The display is very friendly, it’s pretty aesthetic...” When users expressed a feeling after reporting an incident, the segment was coded in the class emotions; when users described what prompted them to report an incident, the segment was coded in the class stimulation; and so on. In above example, that segment of text was coded using the UX dimension visual and aesthetic experience.

After being coded with respect to UX dimensions, all segments of text passed a second round of analysis which aimed at cross-checking scenarios of use that might contain description of tasks supported (or that should be supported) by the Ubiloop application. For example, the segment “If the photo is blurred or taken from too far, I would add a textual comment to explain the incident...” described the user’s attitude when performing a scenario that is associated with the task group “describe the incident”. For that, we have used the reference task model described in Table 3. If segments of text contained references to users’ activities, segments were coded according to the corresponding task. Segments that did not contain any reference to an activity (for example, when users only expressed opinions about the application) were not coded according to the reference task model but they were still considered for the analysis of UX dimensions.

We then counted the number of segment of text that had been coded according to UX dimensions and/or user tasks. We proceeded with independent counting for data collected in early and in late phases of the development process. Once findings had been analysed for each phase of the development processes, we displayed them in a table to compare the results.

4 UX evaluation in early phases of the development process

In the very beginning of the project, we conducted two series of interviews: *semi-structured requirement interviews* and *scenario-based interviews*. Each series of interviews involved nine participants; all of them were French native speakers and lived in France in the Toulouse metropolitan area for at least two years. However, none of them had used an application to report incidents using a smartphone before. All participants gave written consent for participating in this study and our institution’s research ethics committee deemed the research “exempt”.

4.1 Semi-structured requirements interviews

These interviews involved six males and three females (M = 40 years old, SD = 15) whose education level

ranged from high school to obtaining a Ph.D. These participants were selected according to a convenience sample from a neighbourhood association who is actively engaged in the local community and ready to actively act when detecting an incident. All participants owned at least one smartphone and used them for different tasks: phones were used to make phone calls ($n = 9$), send short text messages ($n = 8$), receive and send e-mail ($n = 5$), access the internet via the phone ($n = 6$), make photos ($n = 8$) or videos ($n = 3$) and use the geographic positions system GPS ($n = 5$). Participants were informed about the goal of the interview: to explore the utility of smartphone applications for reporting changes or degradations in the quality of the environment. Then, they were prompted to report about:

- (a) User’s perception of places and their environment; e.g. to tell dimensions they consider important for the quality of their environment (either their neighbourhood or working place).
- (b) Negative experiences in terms of environmental quality; e.g. to tell events they have got by in their neighbourhood or working place.
- (c) Personal involvement with problems; e.g. to identify who they think should be in charge of solving problems in their neighbourhood: themselves (personal level) or the local government (societal level).
- (d) Preferred system design; e.g. to tell how they would like to report degradations of the environment (such as incidents) and what kind of technology should be used (for example, Web service on PC or smartphones).
- (e) User experience dimensions they think important; e.g. to name elements that are important for a good experience or a good quality of the service.

4.2 Scenario-based interviews

For the scenario-based interviews, we invited six males and three females (M = 27 years old; SD = 6). These participants represented a younger population compared to the participants from the first interview. Participants had a broad knowledge on various forms of information and communication technologies, using mobile phones and Internet frequently. All nine participants stated to use their smartphones for calls and sending text messages, eight use it for mail and accessing Internet via the smartphone, seven use it for making photos/videos and seven use the GPS function.

For this interview, participants were asked to consider a set of the seven scenarios. Participants were introduced to each scenario and then asked to explain how they would envisage reporting the incident using their smartphones.

The scenarios were chosen to represent the most common incidents in the area of Toulouse and thus should reflect the most frequent types of incidents supported by existing systems. Moreover, each scenario was designed to highlight a specific context of use. The incidents explored in the scenarios included:

1. *Broken street lamp* This incident was chosen to explore situations that would be difficult to illustrate with a picture. Broken street lamps are often noticed during the night which makes photos almost impossible as many smartphones do not have a flash or it does not cover long distances. The scenario provides some geographic information to prompt if participants would use photos when reporting the incident.
2. *Pothole* The pothole incident was designed to investigate users' personal involvement. It describes people riding a bicycle over a pothole and then feeling back pain afterwards. This scenario is aimed to explore emotions and social behaviour triggered by (negative) emotional experiences with incidents.
3. *Missing road sign* The scenario of a missing road sign takes into account possible limitations for using a smartphone to report an incident when people are in movement, for example driving a car. This scenario explores time/place aspects of incident reporting.
4. *Bulky waste* In Toulouse, waste removal is performed by two different services: garbage trucks collect any waste that fits into the standard waste containers on a regular basis; however, to remove bulky waste, people need to call the local administration for booking a larger truck; otherwise, the waste will remain in place causing a nuisance. This scenario explores how (active) usage of services can prevent incidents, what knowledge people have about local administration procedures (e.g. who to call), and people's previous experiences with local administration.
5. *Hornets' nest* This scenario depicts a hornets' nest close to a playground with some hornets flying around people. It is aimed to explore the influence of perceived danger on the incident reporting.
6. *Tag/graffiti* In this scenario, the participant is told to be on the way to an appointment when he/she notices some fresh graffiti next to his car; participants are prompted to report this incident even if they are in a rush. This scenario is aimed to explore the perception of the level of nuisance and priority, need of immediate action and feeling of duty towards the society.
7. *Broken bench in a park* This scenario explores difficulties for precisely locating incidents. It also prompts people for their involvement with (a priori) minor incidents.

5 UX evaluation in later phases of the development process

In this section, we present the materials and methods employed to assess a high-fidelity prototype of the Ubiloop application. For this evaluation, users had to use the Ubi-loop prototype to report an incident for the first time. The data collected for the analysis were obtained through *user testing* and a *semi-structured post-interview*. The user interface of the prototype and the study protocol were delivered in French, because this corresponds to the mother tongue of target users in the study. Similarly, to the study performed in the early phase, all participants gave written consent for participating in this study and our institution's research ethics committee deemed the research "exempt".

5.1 Materials and Ubiloop system description

Ubiloop was conceived as a smartphone application using the framework PhoneGap² that supports the creation of embedded mobile applications using standardized Web technology. It was deployed for iPhone and Android smartphones. Ubiloop supports user tasks as described by the task model presented in Fig. 2. For reporting an incident, a user should fill a form with information describing: the nature of the incident (what it is about), when the incident occurred, its location, who identified the incident, and what the expected outcomes are. Only the nature of the incident and its location are mandatory. Such information can be provided by different means, for example, location information can be provided using a geo-location positioning system or an address, and incident descriptions might contain photos, videos or just a textual user report. Other optional tasks supported by the Ubiloop application are related to the definition of users' preferences (such as whether users want to inform about their identity or keep it anonymous whilst reporting an incident), history and outcomes of previously reported incidents and discovery of incidents reported by other users in the neighbourhood.

Figure 3 illustrates the main functions supported by the prototype. Figure 3a depicts the icon that identifies the application in the smartphone environment. Figure 3b shows the main menu when the application is launched; this menu enlists (top down) several options allowing users to: start an incident report, inspect incomplete reports waiting for user validation, visualize history of previous reports, configure preferences and visualize incidents reported by other users. In order to specify the nature of an incident, users must navigate a menu featuring taxonomy of categories and types of incidents (see Fig. 3c, d). That taxonomy helps guiding the users through the types of

² PhoneGap. Available at: <http://phonegap.com/>.

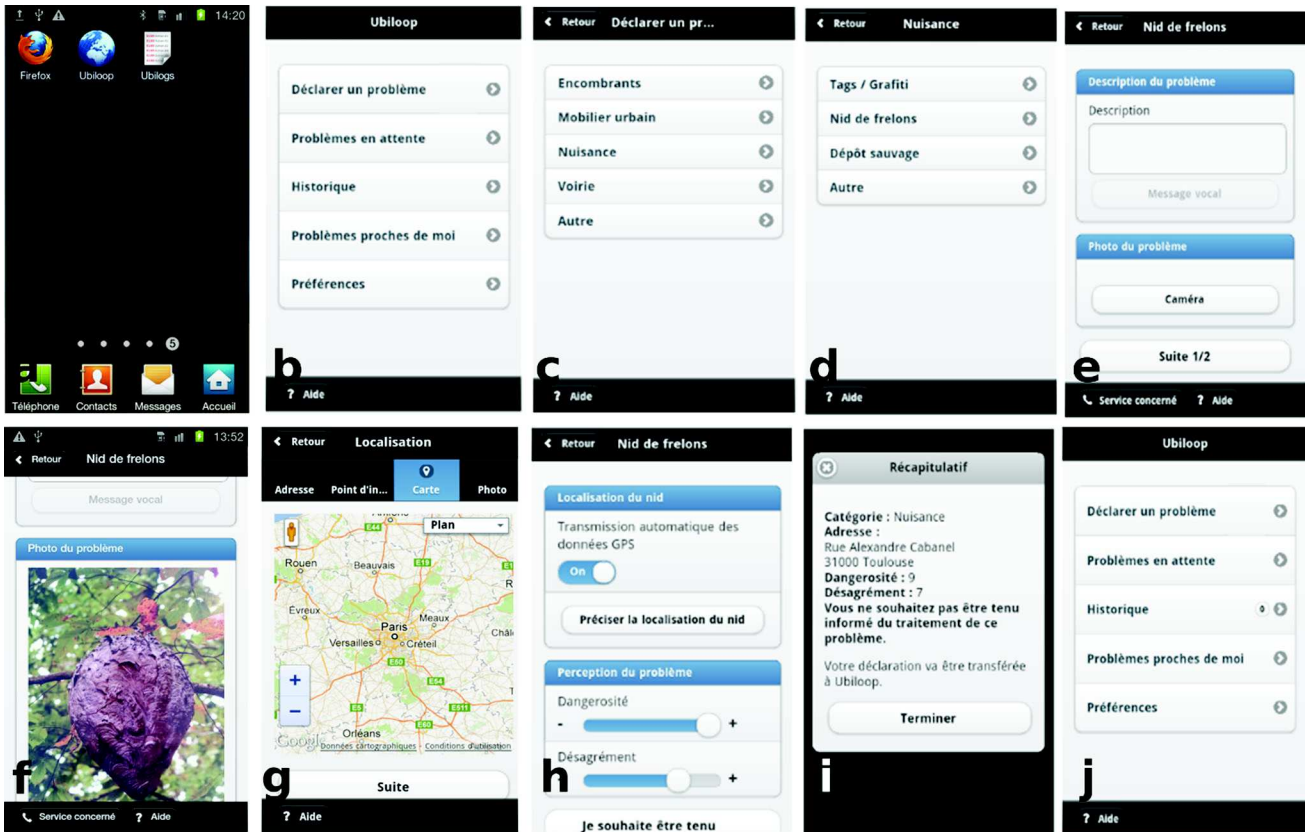


Fig. 3 Screenshots from Ubiloop: **a** application in the smartphone environment, **b** main menu, **c** selection of category, **d** selection of incident type, **e** textual description, **f** photo taken by the user,

g incident location on an interactive map, **h** perception of danger and inconvenience, **i** summary before sending report and **j** main menu featuring a counter of reported incidents

incidents supported by the application. The hierarchical menu reduces ambiguous initial entries that would be difficult to identify if the users had to type the nature of the incidents every time.

The level of information accuracy might vary according to the type of incident. For example, street addresses are useful to locate broken lamps but the exact location is less relevant for reporting noise. Identification of potholes can be anonymous but user identification might be necessary by the administration for reporting noise caused by neighbours (e.g. to prevent false alarms). Therefore, Ubiloop is tailored to request only the minimal information needed to correctly identify the incident. For that, fields in the form change according to the incident type. In case the incident type is not enlisted, the user interface provides an alternative based on a free form. As part of the description, users can also provide evidence of the incident such as photos (see Fig. 3e). Similarly, it is possible to connect to GPS to get the exact user location. The location can also be indicated by typing an address or selecting the location of the incident in an interactive map (see Fig. 3g). Users are systematically prompted to inform the incident's perceived degree of danger and the

disturbance it causes (Fig. 3h). They can create/edit reports as often as required before submitting them. However, if citizens wish to follow-up the outcomes of their report, they should explicitly request it during the submission process. Users are given a short summary of reports (Fig. 3i) and history that keeps the list of incidents reported (Fig. 3j).

5.2 User testing and semi-structured interviews

At this phase, the main goal of the study was to identify UX dimensions that affect the episodic user experience. For that, we observed participants using the Ubiloop application for reporting an incident for the first time. In order to make sure that all participants would report similar incidents during the test, we created some scenarios that highlight specific context of use for reporting incidents with smartphones. User comments were obtained by asking participant to *think aloud* whilst using the application (noted in the *think aloud protocol*), and then to answer a set of questions during the *semi-structured pots-interview*. The *post-interview* immediately followed the *user testing* so that we present them altogether.

We used a convenience sample to recruit 20 participants (eleven male and nine female) ranging from 21 to 57 years ($M = 34.95$; $SD = 11.29$). We recruited experienced and frequent smartphone users to prevent problems arising from first time experience with the devices. Seven participants (35 %) had iPhones whilst thirteen (65 %) used Android as their smartphone operating system. All participants were familiar with a variety of services on their smartphones including: making a phone call, text messaging, sending email, accessing the Internet, taking pictures, using the GPS and downloading applications (e.g. weather forecast apps). None of them knew the Ubiloop application before the user testing session. Participants lived in the same metropolitan area for at least 1 year. Among the participants, nine were home owners, ten were tenants and just one still lived with their parents. Only six participants declared to be engaged in associative activities, from which two worked for a neighbourhood association.

At first, the participants got a short introduction about the experimental study, they were then asked to sign an agreement to participate in the experiment and to fill in a form with demographic data. Subsequently, participants were asked to think aloud and they received a smartphone (either IOS or Android, according to their familiarity with one of these platforms). The participants were then asked to perform the tasks with the prototype whilst following a predefined route on the campus of the University Paul Sabatier, Toulouse, France. The route was populated with posters prompting users to report fake incidents including: *a broken street lamp*, *a broken bench in a park*, *garbage disposal* and *a hornet nest*. The use of the posters for showing the incidents prompted users to the same incidents and prevented users to get in contact with incidents that could cause harm in real life, such as hornets' nests. After completing the tasks, users were asked to fill in three standard questionnaires including *Standard Usability Scale (SUS)* (Brooke 1996), *Self-Assessment Manikin (SAM)* technique (Lang 1995) and *Attrakdiff* (Hassenzahl 2004).

The study was concluded with a *semi-structured post-interview* during which users were prompted to freely talk about:

- Incidents that they might have seen but could not declare with Ubiloop;
- Whether (or not) incidents reported during the user testing were representative of what the users would like to report in real life;
- What kind of incidents they would like to report beyond those currently supported by the tool,
- The users' interest for an application such as Ubiloop;
- Three positive and three negative things in Ubiloop;
- Three words for describing Ubiloop.

For the purpose of the present work which is focusing on the identification of UX dimensions, only users' comments provided during the *thinking aloud protocol* and *semi-structured interviews* are taken into account.

6 Results

In this section, we analyse the UX dimensions found after coding the segment of texts according to the method presented at Sect. 3.3. As the Ubiloop application played a major role in the experimentation run in late phases of the development process, we start by portrait its overall qualities using the standard questionnaires SUS, SAM and AttrakDiff. Only then, we compare the findings in terms of UX dimensions found in early phases of the development process and the interpolation of UX results with respect to the user's tasks.

6.1 Overall quality of the Ubiloop application

The average SUS score was of 83 points on a scale from 0 to 100 (min = 67.5, max = 97.5). This means that the current version of the prototype is considered usable. However, two participants judged the application's usability as average. This might be explained by a few usability problems related to the setting of user preferences and lack of guidance for recovering from interrupted reports. Concerning the questionnaire SAM, the results shows that the application leads users to a positive emotional state. The dimension pleasure received a score of 7 ($SD = 1$) similarly to the dimension dominance (7, $SD = 2$). However, arousal is pretty low with a score of 2 ($SD = 1$). In general, the small standard deviation shows that user's answers are coherent. However, it is interesting to notice that the values for dominance vary more (between neutral and positive dominance). Overall, the SAM score indicates that users might obtain a moderate pleasure when using our prototype to report incidents and have the feeling of being in control of the system. The analysis of UX dimensions took into account the AttrakDiff, thinking aloud and the interview. Similarly, the results obtained from AttrakDiff are very encouraging. All participants (regardless age, level of education, genre or experience with smartphones) provided very similar scores, indicating that the overall user perception of the application is coherent. The application was perceived as pragmatic, which means useful, usable and generally task-oriented. The hedonic qualities are good, but the UX could be improved by improving the dimension stimulation and visual aesthetics.

6.2 Main findings in terms of UX dimensions

The analysis of the users' comments revealed segments that fit in six UX dimensions: visual and aesthetic experience, emotions, stimulation, identification, meaning and value and social relatedness/co-experience. The results presented in Table 4 summarize the analysis of 506 segments of texts extracted from the two series on semi-structured interviews (i.e. *requirements interview* and *scenario-based interview*) performed in early phases of the development process, and 436 segments of text obtained with the methods used during the user testing of the Ubi-loop application (i.e. *thinking aloud protocol* and *semi-structured post-interview*) (Table 4).

It is interesting to note that the identification of these six dimensions consistently occurred whilst coding users' comments obtained from the diverse methods employed in early and late phases of the study. The consistent identification of dimensions can be seen in the graphic presented in Fig. 4 which indicates the percentage of participants who raised comments allowing UX coding. The number of participants is presented as a percentage to allow the comparison of unequal user populations who took in part in the study (18 participants in early phases versus 20 in the late phase). Figure 5 shows the number of segments of text classified in the six UX dimensions.

Hereafter, we illustrate how each dimension is perceived to affect the design and the usage of incident reporting systems. In order to allow the identification of participants, we adopted the following naming convention: comments raised by participants in early phases of the development processes are labelled from P01 to P18, comments raised in late phases of the development are labelled from U01 to U20.

Visual and aesthetic experience: based on the number of segments referring to *visual and aesthetic experience*, we can say that regardless of the methods used and the phase of the development process, this dimension was considered less important than other UX dimensions by the participants. Nonetheless, *all* participants seem to be concerned about the quality of photos as mentioned by the participants. Similar comments about the quality of photos were reported during the *user testing*. It is interesting to see that the people want to provide a good and clear picture of the incident, and perceive that aspects as important to establish a trustful relationship with the local government. This aspect creates a link between visual and aesthetic experience and the overall trust on the e-government service, as mentioned by P15 during a *scenario-based interview*: P15: "If the photo is good, they [the local administration] will see the problem..." and U11 during user testing session: "If the photo is blurred or

taken from too far, I would add a textual comment to explain the incident..."

Other elements of the design that are associated with *visual aesthetics experience* reinforce the bond with the user and the trust in the prototype as illustrated by the user U05: "...I like the simplicity in the design, but there is something missing here. I guess the design should be different. For example, a trademark symbol TM or © should be added to reinforce the credibility one might have in the application..."

Emotion: the *interviews* and *user testing* identified positive and negative emotions that are related to how people perceive places and their environment (place identity) and to the various levels of the domestic environment. Emotions were also judged important to design, as the application can be a means to overcome negative experiences, and the reporting of an incident affects users not only in terms of positive emotions (joy), but also influences long-term perceptions (pride). Thus, three sources of emotions have been identified: emotions associated with the quality of the user environment, negative emotions associated with the occurrence of incidents and (positive) emotions that can be attributed to the use of the system.

Participants expressed positive emotions when they mentioned their pleasure to be in a "high-quality" environment. They mentioned that an incident reporting system might not only help to improve the quality of the environment but also contribute to an overall positive emotional state. For example, some participants said that the application could allow them to experience positive emotions of pride and enthusiasm, especially from having the opportunity to contribute to the improvement of the environmental quality of the city, as mentioned by P18: "...I would be very happy to do that [to report a broken bench]. So the national proud of Toulouse is increased." Enthusiasm was perceived in comments collected during user testing experiment, as follows (U11): "... The prototype is fun and easy to use. It is interesting indeed as it [the incident reporting system] allows us to have a different point of view about our neighbourhood..."

Negative emotions were found in both studies associated with previous experiences with incidents and in particular with incidents directly involving the user (e.g. an accident with a pothole whilst riding a bicycle). They were related to the degree of influence participants perceive to have on the domestic environment, like the perception of overpopulation due to a large number of new buildings in the area, or the increasing level of noise due to heavy traffic.

There are some positive emotions that can be attributed to the use of a system, in particular, when the system helps users to overcome a negative experience. For example, participants mentioned that the application could help them

Table 4 Number of segments identified and coded according six UX dimensions during the study

UX dimensions	Findings in early phases (interviews only)			Findings in later phases (after using the prototype)	
	Users reporting the dimension in requirements interviews (population $N = 9$)	Users reporting the dimension in scenario-based interviews (population $N = 9$)	Total of segments (requirements interviews + scenario-based interviews)	Users reporting the dimension in user testing of prototype (population $N = 20$)	Total of segments in user testing (thinking aloud + post-interviews)
Visual and aesthetic experience [AX]	6 (66.7 %)	6 (66.7 %)	21 (4.2 % of segments) ~ 1.2 segment/participant	10 (50 %)	12 (2.8 % of segments) ~ 0.6 segment/user
Emotions [EM]	9 (100 %)	6 (66.7 %)	61 (12.1 % of segments) ~ 3.4 segments/participant	13 (65 %)	25 (5.7 % of segments) ~ 1.3 segments/user
Stimulation [ST]	9 (100 %)	2 (22.2 %)	29 (5.7 % of segments) ~ 1.6 segments/participant	20 (100 %)	105 (24.1 % of segments) ~ 5.2 segments/user
Identification [ID]	9 (100 %)	9 (100 %)	150 (29.6 % of segments) ~ 8.3 segments/participant	19 (95 %)	101 (23.1 % of segments) ~ 5.3 segments/user
Meaning and value [MV]	9 (100 %)	9 (100 %)	110 (21.7 % of segments) ~ 6.1 segments/participant	19 (95 %)	111 (25.4 % of segments) ~ 5.6 segments/user
Social relatedness/co-experience [CX]	9 (100 %)	9 (100 %)	135 (26.7 % of segments) ~ 7.5 segments/participant	18 (90 %)	82 (19 % of segments) ~ 4.1 segments/user
	Total = 506 segments ~ 28.1 per participant			Total = 436 segments ~ 21.8 per participant	

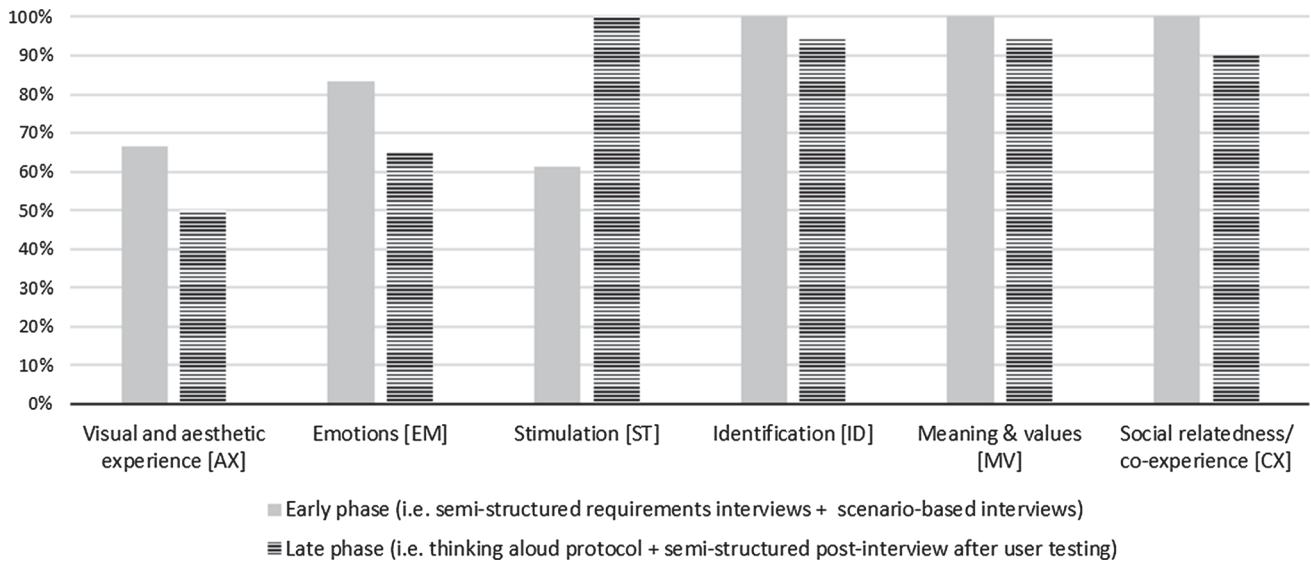


Fig. 4 Number of participants reporting UX dimensions in early and late phases of the development process

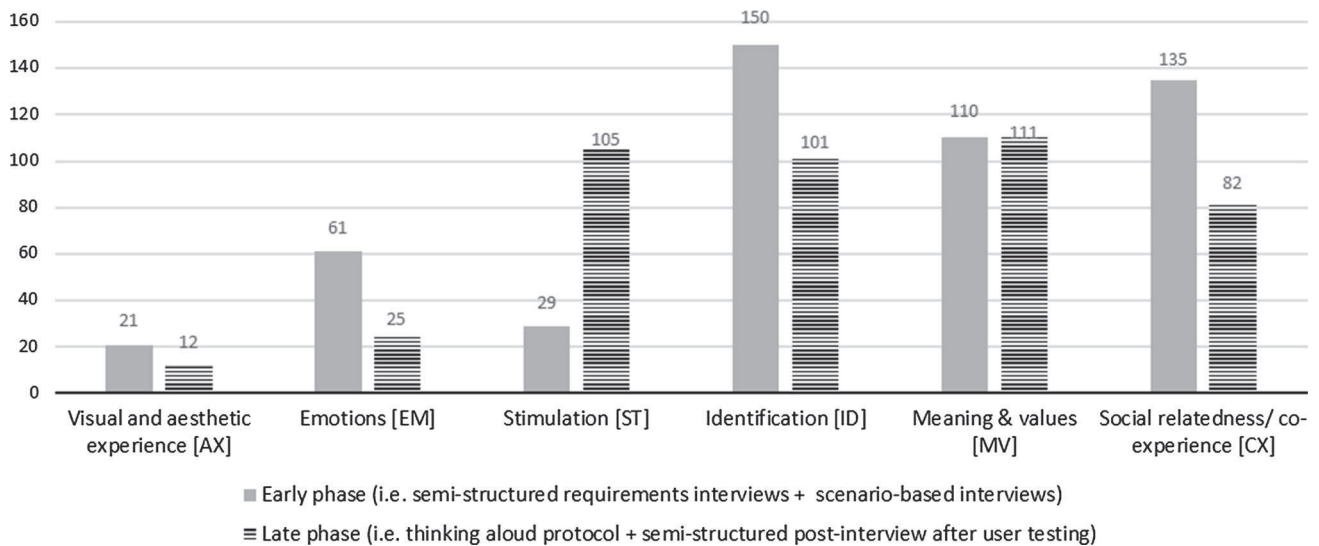


Fig. 5 Number of segments coded according to UX dimensions in early and late phases of the development process

to overcome the (negative) emotional perception and, eventually rationalize the experience, if they are allowed to express themselves via the incident reporting system. Nonetheless, these emotions can be influenced by users' ability to use the application, as quoted below, P13 said: "...under the influence of anger, there is a chance that I miss to report the required data and that as a result the reporting [of an incident] is not considered. So they [the system] should use a text field to require users to think a little and calm down..."

During interviews, we could identify negative emotions also resulting from fear that an incident report might lead to a reprisal. This is illustrated in the dialogue between the

interviewer and the participant of the *semi-structured interviews*, interviewer: "So the problem is to take pictures, so if you make a picture you are afraid that there will be a kind of retaliation?" P03 replied: "Yes, I got this... this kind of feeling. Yes."

Whilst the fear of reprisal and/or impact of denunciation occurred many times during interviews, it was completely absent during the user testing sessions. Some users felt afraid of a "big brother effect", though, as shown by user U07 during user testing: "I don't like the idea that we should report everything. If this behaviour becomes excessively frequent in the society, I would be very upset."

Stimulation: participants often mentioned that if they were allowed to see incidents reported by other citizens, they would feel stimulated to look for similar problems in their neighbourhood, especially if these incidents involve ideas for improving the quality of life in their neighbourhood. For example P4 said: "...I even find it difficult to imagine that [the incident], unless someone talks to me about it. Perhaps the application could prompt us to look at some incidents or perhaps we could see what others have reported and [to incidents that] I am not sensitive to [perceive them]..."

Being able to report incidents with a smartphone can be an incentive to be an active member of the (local) community and thus start a relationship with the local administration. It is noteworthy that this dimension is also related to the perception of vigilance that can involve the security in the neighbourhood, which can be considered beyond the scope of incident reporting systems addressed in this work. For example, P02 said: "...Having this application [i.e. an incident reporting system] may give the consciousness of a kind of mission, of vigilance. So one can say that one would not miss any incident, this may encourage people to go out for a walk, instead of staying at home..."

Whilst similar comments occurred during the *user testing sessions*, these outnumbered three times the segments found for the UX dimension *stimulation* during early interviews. Segments related to *stimulation* were frequent during user testing, thus suggesting that the presence of a running application (and maybe the possibility to use it in real life) might have a stimulating effect on users: U12: "... if the application prompts me to report an incident, I would do a report whenever I've found one...", U08: "... without such an application, I would never report graffiti..." and U18: "... now that I know this kind of application exists, I would look for incidents [in my neighbourhood]..."

Identification: was found in association with the identification with a place (place identity) that supports the diagnosis of the incident (sensitivity to the types of incidents), willingness to report an incident (personal values, attachment to places), and identification with the means available for reporting incidents (e.g. smartphone).

The Identification (identity/personality) concerns personal values but also the willingness to act and to perform citizen duties, for example (P03): "...Well, maybe my perceptions are a bit unusual compared to others, but I see lots of things to report... It's in my nature, I am open, and so I'm reporting back information [to the local authorities]. That's it". We have also observed some elements of personality and personal behaviours coming out during user testing (U19): "...I think that it is important to only send accurate information. But my option might have been

affected by my actual job. Indeed I am expert in security I always have this kind of concerns in mind during the testing session..."

The willingness to report an incident as expressed by P14: "Well if it's a bench on which I used to sit with my family every Saturday afternoon... yes... it will make it [to report an incident] stronger. But if I just passed by and I never use it, well I do not even know if I would see that it is broken." Similar findings were found in user testing (U08): "I would report incidents in the children park because I am personally concerned by this type of problem..."

The level of identification with the smartphone is a positive promoter for incident reporting. This element is clear in both *early interviews* and during *user testing*, for example P11: "Usually I cannot forget the appointment with the bulky waste, because I note everything on the agenda of my smartphone that I have always with me..." and U13: "I didn't have to think [learn] much before start using the application, it is very well integrated to the smartphone. Indeed, I didn't have to learn anything new, which is good..."

Meaning and value: the value of the incident reporting is influenced by the perception users have about the utility of their incident reports. In general terms, participants think of incident reporting systems as worthy in three situations: (a) to provide a reliable evidence of existing incidents, (b) to provide personal identification, as evidence of the individual commitment and (c) to rely on users reporting the same incident. For example:

P14: (a) "For this incident I want to take a photo as a proof. In this way they can trust me."

P04: (b) "If we do not identify ourselves, everyone will begin to send anything and everything. Because there are always idiots who play around and misuse applications. So the service loses its value if invaded by spam."

P17: (c) "I see an interest in knowing that other people reported the incident, like that according to the type of incident, I will make an additional incident report to give more importance to the incident, to be sure the incident will be considered by the service."

The value of incident reporting systems can be reduced if it is misused to denunciate someone or to transfer the work from an administrative agent to citizens. These findings are similar in both *interviews* and *user testing sessions* as illustrated by P01: "Well, it must be of good citizenship anyway. This is the civic duty, it is not denunciation. And the service must work in this spirit", P16: "...Yes then it does not have the exact location of the pothole, but... it is agent's duties to be careful to locate it [the incident] in the field. Otherwise I will feel I'm doing the agents' job, which completely devalue the service."

and U14: "... The application should have a clear purpose and provenance. This is important. At least for me... For example, I would not trust on an application provided by a third-party company, but I would trust an application provided by the Toulouse administration."

The dimension of meaning and value is also directly influenced by the perceived efficiency of the local administration/government. If an incident is reported but never solved, participants told they would be keen to abandon the application, as stated by P12: "... on this type of incident I would like information from the back-end service. How do they tackle the problem? Are they going to fix it? And at least, if they have understood it [the incident report]? Otherwise it will give the impression that it is useless to make reports and then I'll stop making them" and U18: "If there is someone providing feedback [about incidents reported], then I would use the service more often. I would feel that my claims were listened to..."

Users value the fact that the system can help people to report incidents that have not been seen by the administration, U14: "...The local administration cannot be everywhere... So helping the administration [to see where the problems are] is a good thing..."

Social relatedness/co-experience: what became evident during the *interviews* in early phases is that participants did not perceive the incident report as part of their duties, but they felt it more like an act of sharing information. It is like a tweet (twitter message) that helps them getting in touch with the local administration. In this sense, from the user's perspective, we have to consider the m-government service of incident reporting as a special type of social network. This is clear in the example below where a participant identifies incident reporting as that social network:

P11: "I take a picture of the broken bench. Then I press the "Share" button. In the smartphone a bunch of social networks is shown where I can put the photo. So there I simply diffuse the photo on the community network."

P13: "I do not care that my report is on track, it's secondary. I want a human being to answer me, so I can make sure he understood my problem and if it will be repaired or not. It should not be something automatic; it has to be people who respond."

The participants also expressed the need for sharing information with other citizens. For example, P11: "I guess this will be more or less a community network. So I would probably not be alone in reporting the incident." The segments obtained in early phases are a projection of what users envisage for the future systems and they contrast a bit with the motivation found after using the prototype when *co-experience* is more oriented towards the relationship with authorities and the perception of danger, for example

U13: "This weekend I saw a hornets' nest and I thought I should have left a message to other people passing in the area...", U11: "Notifications should be sent systematically to inform that the incident has been received [by the administration]. A mail explaining when the incident will be treated must follow. If the problem is a hornets' nest they should also inform all people around when the problem has been solved..."

6.3 Analysis of segments with respect to the reference task model

Once the segments of text were coded with respect to UX dimensions, they were cross-checked for the occurrence of scenarios that could be associated with the reference task model as shown in Table 5. Based on the association of UX dimensions to tasks via the interpolation of user scenarios, it was possible to extrapolate the results in a single task model as shown by Fig. 6. The model is decorated with rectangles that represent different UX dimension (such as [AX] for visual experience, [ID] for identification). These decorations aim at highlighting where, during the task executions, UX dimensions were found important by participants of interviews.

In order to illustrate how the task model presented in Fig. 6 should be read, we provide hereafter an extended scenario including UX dimensions:

I am passing by at this park every Sunday and this bench has not been repaired for weeks [ID]. It now is the time to report that [ST], so it will get fixed. It is not really a problem or unsafe, but the bench is simply not usable in the current state [MV]. [detect/recognize the incident]. It seems important now to make sure that the appropriate person is informed about that bench [CX], I think I should use the application to report the incident, because I want to be a good citizen [ID]. I think it is a good idea to send them a photo so they can see that the bench is really broken and that the wood has to be replaced. And when they see the photo they see that it is really there and so they will not need my contact information to have a proof that the broken bench really exists [MV] [describe the incident]....

The example provided in Fig. 6 shows how user tasks are interrelated to the UX dimensions. The various user experience dimensions do apply for the sub-tasks to a varying degree. We just refer to the most important UX dimensions in the diagram. All user experience dimensions have been associated with the sub-tasks. It is interesting to notice that some tasks (such as [provide a picture/video]) can be influenced by more than one UX

Table 5 Synthesis of the interpolation of UX dimensions, user tasks and implications for the design of incident reporting systems

UX dimensions	User tasks	Implications for design of incident reporting systems
Visual and aesthetic experience [AX]	–	All users express their preferences for dedicated applications for incident reporting, mainly for aesthetics reasons. Thus, design options should be generally supported by smartphone applications dedicated to incident reporting rather than a web application running on the mobile phone's browser. However, users wish to have a website on a larger PC display to see a map of all reports in their neighbourhood
	[Provide a picture/video]	Users consider good pictures as more valuable and significant for incident reporting. So, the service should provide guidance to take pictures with a good visual quality (e.g. through photography tutorial)
Emotions [EM]	–	Declaring incident helps users to improve the quality of their environment. This contributes to an overall positive emotional state
	[Select incident category]	Some types of incidents would generate negative emotional responses. For example "dangerous" animals like hornets, rats or snakes are sources of phobia. The system should help users to regain their calm by reporting the incident and by providing safety instructions
	[Rate potential danger]	Rate the perceived danger of an incident is a means to express a negative emotion, especially when users had been involved in the incident (see case study of the pothole). It's helpful to regain calm and rationality. So, design option should provide sliders to rate incidents
Stimulation [ST]	–	Some users declared that they would be proud to help local administration to improve the environment quality. Design options would be to support collective incident reporting as events/games (i.e. organized by local administration) in order to improve the emotional involvement with the service
	[Submit an incident report]	Smartphone applications that provide an easy and fast way to submit a list of incidents also stimulate users to submit incidents. Design options should globally favour efficient application integration in the smartphones' operating systems
	[Select incident category]	Incident categories are a good means to prompt users to recognize and then declare different types of incidents. Nevertheless, incident categories should be short (i.e. 5 items through 3 levels) to avoid short terms memory workload
Identification [ID]	[See someone else's reports]	Looking at other reports is a good means to share different users' points of view and also to recognize problems encountered by different citizens. Users prefer to make this activity at home on a website. Design options should provide interactive maps, including filters, available on a website
	[Decide to report the incident]	The decision to report an incident is a consequence of both the user's personality (e.g. citizens' duty) and the means to do it In terms of design implications, the users should have a means to instantly report an incident when they perceive it. For now, this means should be his/her smartphone including a dedicated app
	[Identify who should solve the incident]	The users expect to know the effective means, benevolence and aims of the e-services, and generally how the service can work. This is important because it's a pre-condition (for users) to use and to be confident with the system In terms of design solutions, this should lead to a video and/or a webpage describing the service's intentions, means, policies and workflows
Meaning and value [MV]	[Provide a description]	Users involved in incident declaration would like to provide valuable reports. So, according to the incident type, users would like to provide (at least) the mandatory data A design solution should be to provide a kind of template and/or a tutorial explaining how to provide efficient incident description. For this point, the guidance of users is important, especially for potentially dangerous incidents
	[Locate the incident]	The location of an incident is a mandatory issue for incident reporting. So users would like to provide a good description of the location of the incident. Most of them suggest using cardinal coordinates (i.e. by use of GPS). However, some users would also like to keep the control on the transfer of these coordinates. Indeed, some users identify cardinal coordinates as private data and would like to transfer them only after an explicit action or confirmation So in terms of design solution, the user should be able to allow (or avoid) automatic location, for example in a "preferences" menu of the app

Table 5 continued

UX dimensions	User tasks	Implications for design of incident reporting systems
	[Provide user ID]	Users consider their identification as a credibility cue of their reports. They also consider identification as a means to prevent the service from fake reports. Nevertheless, some users expect to have an option for automatic identification, for the purpose of effectiveness, but another part of the users would like to transfer their identification after an explicit action So, as in location, a design option should propose an option between automatic and explicit identification (e.g. in a preferences menu)
	[Subscribe for notification]	Notifications are a cue of the local administration's capability to manage/solve incident reports. Depending on the incident type and the level of user involvement with the incident, users would like to get informed of IR evolution A design option, during the IR procedure, should propose the possibility to freely subscribe to notifications to users
	[Share reports]	Users consider the different signs of the service activities as cues of value and credibility of the service In terms of design options, a means to share reports with local administration or citizens would be a means to appreciate the overall activity of local administration in order to solve incidents
Social relatedness co-experience [CX]	[Identify who should solve the incident]	Users will share information only if they estimate that information would be taken into account by at least one service. So, in order to prompt users to report incidents, it is important to indicate which service is in charge to take into account which type of incident (e.g. in the notifications, on the website describing the service workflow)
	[Provide a picture/video]	Pictures or videos are a good means for users to explain the incident and its context to someone else. The service should help users to take efficient picture of an incident, for example through a tutorial
	[Call a hot line]	Some users would share their experience of an incident directly by phone, especially for dangerous ones (e.g. Hornets' nest). Furthermore a phone call is a direct means to assure users that the local administration shares the same comprehension of the incident. Thus, the app should provide a means to call a hotline, according to the incident type
	[Subscribe for notification]	Users do not expect automatic responses. The service should provide a reformulation of incident report by human agents
	[Share reports]	Sharing information is important to build and keep a community around incident reporting activities (i.e. between administration and citizens). Design options should provide interactive maps with filters to show/locate the different incidents. Subscription to RSS feeds would also be a solution to share reports with other citizens. These kinds of activities should be supported mainly by dedicated websites for usage at home

dimension (such as visual and aesthetic experience, and social relatedness/co-experience), whilst other tasks can be considered neutral with respect to UX dimensions, which means that, even if necessary for the system, these tasks do not raise any particular user experience. One possible implication for this association is that if designers want to reinforce or create a specific UX dimension they might work on the tasks that might have an impact on users.

Table 5 illustrates tasks that are reported in conjunction with the expression of UX dimensions. The distribution of segments of text according to the two phases of the study refers to the contribution of the number of segments coded in specific dimensions for the total amount of segments found in the phase (e.g. 4.2 % for UX dimension *visual and aesthetic experience* refers to its overall contribution of 21 segments in a total of 506 segments coded from interviews in early phases of the development process).

From the twenty-six sub-tasks identified in our reference task model, only 13 tasks were present in the segments reported by the participants of interviews and in the user testing. For example, participants never mentioned anything that could be interpreted as being associated with tasks such as *rate the inconvenience* [of an incident], *pin-pointing* [an incident] *in a map or using landmarks*. Participants in all studies never mentioned tasks such as *when did incident occur* or *record when the incident is reported*, which have an overall impact for understanding time constraints associated with incident reporting. Also, none of the participants mentioned the task to *cancel a submission* [of the incident]. It is quite interesting that we have found a very similar coverage between tasks reported by users during interviews and tasks reported during user testing.

It is also worthy to notice that some tasks could be associated with more than one UX dimension, for example

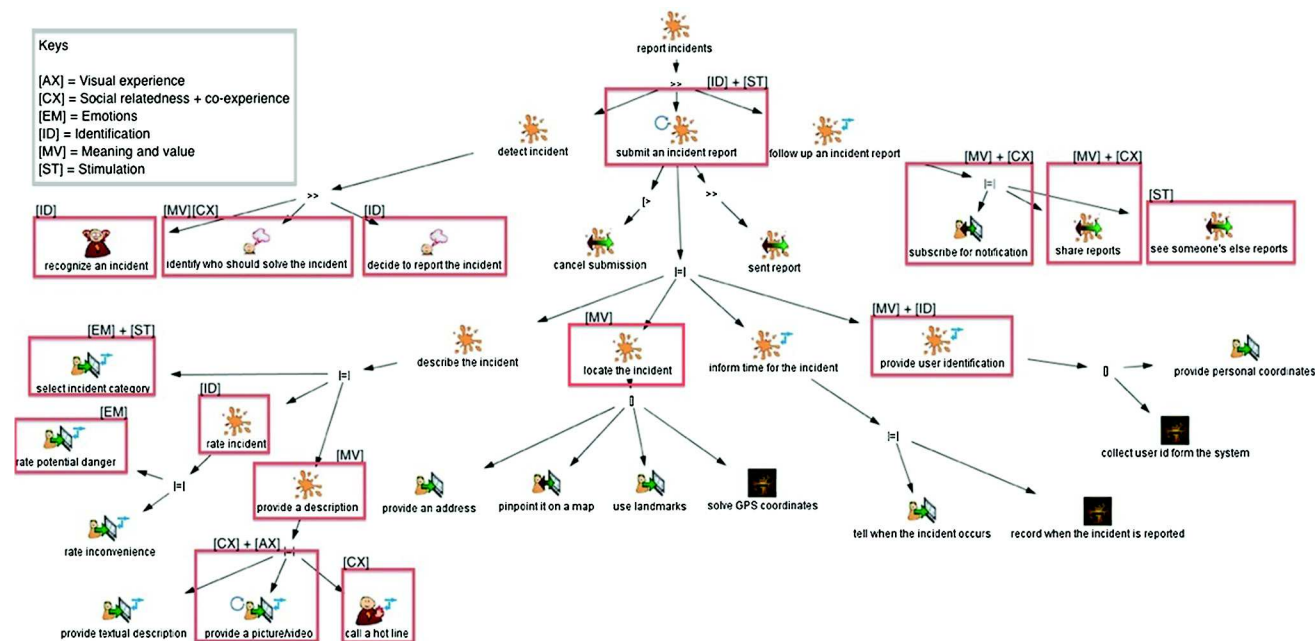


Fig. 6 Generic task and most important UX dimensions for each sub-task

provide picture/video, when users mention the quality of the photos (interpreted as part of the UX dimension *visual and aesthetic experience*) for helping the authorities to understand the incident (interpreted as UX dimension *social relatedness/co-experience*).

7 Conclusions and future work

This paper provided two main kinds of contributions that are worthwhile to be discussed: the first one refers to the knowledge that can be obtained in terms of UX dimensions affecting incident reporting systems; the second refers to the methodological aspects involving a method based on the coding of users' comments and their subsequent interpolation with a task model. Given the fact that data were collected in early and late phases of the development process, we can discuss the results in terms of anticipated UX and episodic UX (after using the Ubiloop application).

The investigation of incident reporting systems in the e-government domain is quite new. Despite the fact that many applications exist, we could not find any detailed analysis about the user tasks for declaring incidents. The lack of detailed analysis of user tasks can explain, at least partly, problems such as late adoption and definite rejection of applications. A significant result from this study is point out how UX dimensions can be associated with task engaged by users. The methods used showed several social implications for the task of reporting incidents in an urban context. These social implications can be translated into

several UX dimensions such as emotions (that motivate users to report an incident), user identification (that tells to which particular incidents user are willing to spend some time for writing a report) and visual experience (how aesthetics affect user perception of the system) that might influence the act of reporting an incident.

The sample of participants might be considered small, thus some of the results should be considered preliminary at this point. However, the discussion presented on UX presented in this work might still be considered useful for pointing out where to look for overall user experience improvements with e/m-government applications. We expect that these results could contribute to further research in the field and contribute to build a more general understanding about how UX dimensions affect users of e/m-government applications. The knowledge obtained from user requirements for incident reporting systems can be directly employed in the design of future applications. On the one hand, this can be read as a set of recommendations for designing incident reporting systems (see Table 5). On the other hand, this work has identified how UX dimensions affect tasks for incident reporting systems. So, if governmental agencies want to provide high-quality incident reporting systems, they should concentrate their effort on the design of applications that communicate positive UX dimensions.

The two interviews (*semi-structured* and *scenario-based interviews*) provided evidence for identifying the following UX dimensions: visual and aesthetic experience, emotion, stimulation, identification, meaning and value and social

relatedness/co-experience. These early results in terms of identification of UX dimensions are coherent with the findings during the user testing which did not support the identification of new dimensions. It is interesting to notice that the total number of segments collected remains more or less stable in data collected in early and late phases of the development process (~28 segments per participant of interviews and ~21 segments per participant in the user testing). The distribution of segments in the corpus of segments collected in early phases (interpreted as anticipated UX) and segments collected in late phases (interpreted as episodic UX) remains similar for some dimensions such as *meaning and value* (~6,1 segments of anticipated UX, ~5,6 segments of episodic UX). However, some remarkable differences can be noticed in other dimensions such *visual and aesthetics experience, emotions, identification* and *social relatedness/co-experience* (where the numbers of segments per participants for anticipated UX is nearly the double of the segments collected per user for episodic UX). It is also noteworthy that the inverse effect is produced with the dimension *stimulation*, where the number of segments per user that participated in the user testing is more than three times (i.e. ~5.2) the number of segments collects during interviews (i.e. ~1.6). This might suggest that users felt more stimulated to talk about their everyday life experiences whilst using the prototype which enabled them to report incidents.

Whilst the study allowed us to observe changes between anticipated UX in early phases of the development process and episodic UX in late phases of the development process, the methods used do not allow to determine the root causes of these changes. For example, we cannot claim that *stimulation* will always appear more frequently in late phases of the development process or that *visual and aesthetics experience* are less important than other dimensions. Further studies are required to determine if our finding are generalizable for the development of interactive systems, whether they form patterns that are specific for incident reporting systems, or if these were serendipitous findings of our study.

At this point, we have to acknowledge some factors that prevent us to provide a clear explanation for the observed changes. First of all, we did not use the very same evaluation methods in early and later phases of the study. Second, the pool of users changed from one study to another, so we cannot claim that the changes reflect individual perception of anticipated UX and episodic UX. Finally, there was a gap between the study performed in early phases and late phases of the development process. Nonetheless, all these three factors are part of UX dynamics. Indeed, although the changes in research methods might introduce a bias in the study, we cannot always use the same methods in all phases of the development process, as discussed in Sect. 2.2. We tried to reduce the

impact of changing methods by relying on users' comments and interviews. User's opinions might change along the time, and this might have an impact on the measurements of the UX. Whilst we cannot explain how individuals changed their perception of *anticipated UX* and *episodic UX*, it is interesting to notice that we could still observe changes in a bigger picture when we compared grouped answers. Moreover, regardless of the individuals, it is possible to portray some conclusion based on the context of use of the application, which is more relevant for the design of interactive systems than understanding why users change their opinions when reporting *anticipated UX* and *episodic UX*. We are aware that the timing between the two studies might have affected the results, especially if social aspects favouring adoption of innovative systems are introduced—for example, if users saw publicity about incident reporting systems or have experienced bad incidents that prompted to report them to the administration. These temporal situations might affect users' perceptions, and they are hard to control in a UX study. Despite these limitations, it is still important to take into account these changes of the UX along the development process, and knowing that changes might occur helps us to take better decisions for the design of interactive systems. Further studies with bigger user samples might also help to solve some of these tricky questions about the UX dynamics.

As far as the choice of methods is a concern, the methods used allowed to identify user experience dimensions and combine them with a task model. The task model proved to be useful to anchor the findings expressed by users in terms of users' scenarios that correspond to the general task model, and UX dimensions that were always reported in connection with tasks. Task models were thus used as a kind of "lingua franca", enabling us to identify a set of UX dimensions and their relations to (sub-) tasks of incident reporting. By combining methods, it was possible to provide a clear representation of the tasks and to point out the lack of support for existing applications. This aspect of the present research will certainly help designers to understand which tasks are worth getting more attention to raise certain UX dimensions and eventually achieve or surpass an expected UX result. Conversely, designers can focus on specific UX dimensions and then look at the tasks with which users are more likely to perceive the desired effects. It is noteworthy that instead of using a specific application, we investigate a generic task model from which several scenarios could be extracted and then analysed. This step is extremely important for future development of new incident reporting systems. We suggest that such an approach for task analysis is extremely helpful to cover all design options to achieve a given goal.

Moreover, the results show that the importance of UX dimensions is not equally distributed along the several sub-

tasks citizens engage with when reporting incidents. By using a model-based task analysis, it was possible to remove ambiguities present in the discourse of participants and then formalize user requirements. Moreover, model-based task analysis provided an accurate description of user tasks. As described in Martinie et al. (2011), task models do not only improve the understanding of user tasks, but they also can be used to assess if an incident reporting system was effectively implemented to support the specified set of user tasks.

As far as the use of methods is a concern, the proposed triangulation of methods might provide new insights for interpreting results related to overall user experience and how to plot them into task models, which are aimed to support design activities. The method of interpolation was evaluated to be useful to compare results found about anticipated UX and episodic UX. We suggest that the method could also be used to pursue the investigation of how UX dimensions change over time in the development of interactive systems. In future work, we will investigate to what extent the same method could be used to assess *cumulative UX* (which refers to views on a system as a whole after having continuously used it for a whilst) including periods of non-use.

In the near future, we expect to collect similar evidence from other countries about the impact of UX dimensions on the design of user incident report systems. Our future work will also focus on this aspect to describe in more detail how the different UX dimensions change in terms of importance for the various steps during an incident report, and what UX dimensions do overall support an increase in activity to become an active citizen. Moreover, we want to explore in detail which dimensions of the UX are associated with the use of mobile applications. For that, we plan to perform new experiments with other kinds of mobile applications (than incident reporting systems) to better isolate the aspects of mobile interaction that affect the coding of UX dimensions.

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