Engaging "New Users" into Design Activities: The TERENCE Experience with Children

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Abstract The diffusion of digital technology is bringing new types of users "into the market", like children, elderly people, or technology illiterate people. Designers and researchers have to face new design challenges having at disposal a lighter and less structured body of knowledge about characteristics and demands of these users, and even consolidated design methods may prove to be inefficient. With respect to these issues, and more specifically with focus on data gathering techniques, in this paper we discuss the experience of the TERENCE project, aimed at developing a technology enhanced learning system for improving text comprehension in children 7–11 years old. In particular, our experience suggests extending the repertoire of inquiry techniques with methods shaped and informed by gamefulness phenomena.

Keywords User centered design · Data gathering methods · Children

1 Introduction

The growing diffusion of innovative digital technology in everyday life is extending the population of users both in number and in typology, bringing into the realm of technological products people traditionally not served by ICT.

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Elderly, young people, people with special needs, technology-reluctant and/or technology-illiterate people are just a few examples of not traditional ICT users with novel demands and novel expectations on interactive artifacts, which translate into novel design and research issues.

Technology is successful when it is well contextualized and it is based on a clear understanding of needs, cultural constraints, and behaviors of the persons using it. A rigorous design approach requires that the design solution is iteratively created/developed using state-of-the-art knowledge both from existing theories and successful design solutions and design practices, referring to both the characteristics of the desired product (e.g., interaction techniques, visual elements, gestures) and the design process itself (e.g., methods and grounding theories). In case of new users' typologies, not only designers and researchers rely on a less heavy and often less structured body of knowledge, but even consolidated techniques and methods may turn out to be less efficient, sometimes exactly when and where they become even more crucial than in more traditional application domains. It is desirable that the design is conducted according to methodologies that actively involve users in the design process, like User Centered Design (UCD) or participatory design, which have the positive side effect of favoring the integration of designed artifacts into organizations sometimes new to digital innovations (e.g., schools and hospices). But, if it is reasonable to expect that extensive contextual studies are conducted *with users* to elicit insights on their demands, characteristics, tasks and behavior, it is legitimate to ask whether existing methods for the analysis of the context of use are really adequate for interacting, e.g., with children or elderly or people with special needs.

According to Information System (IS) design science (see, e.g., [9]), theories play a dual role in the design process: they constitute the ground of an artifact construction, and can be the outcome of the design process. Knowledge and understanding of a problem domain and its solution can be achieved by the building and the application of the desired artifact. It is then desirable that the growing interest around new users, and the consequent production of novel ad hoc innovative interactive technology, be characterized by the twofold purpose of building artifacts and enriching related state-of-the-art knowledge. While for an extensive discussion on how HCI and IS design science research may cooperate we refer to [15], we here recall that, e.g., in the case of the so called "second paradigm" in the HCI discourse [8], design and evaluation of artifacts and processes for creating new knowledge are well represented by Hevner's three cycle view [10]: in this view an iterative process bridges the design science activities (the *Design Cycle*) with the contextual environment on the one side (the *Relevance Cycle*) and the knowledge base of scientific foundations, experience and expertise on the other side (the *Rigor Cycle*), as sketched in Fig. 1. Particularly in the case of new user types, it is hence expected (1) a considerable work in the Relevance Cycle and (2) additions and extensions of original theories and methods in the knowledge base, gained from performing the research and from testing the artifact in the application environment.

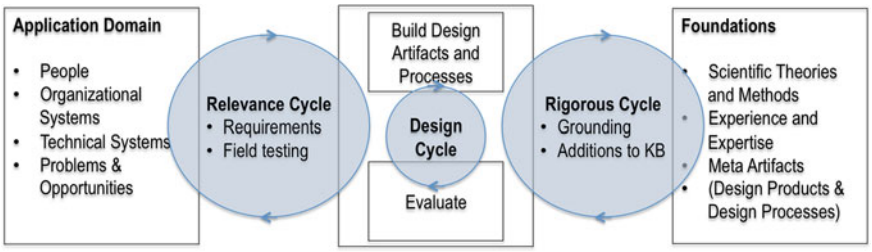


Fig. 1 Hevner's three cycle view of design science research

According to this view, in this paper we report the experience gained within the TERENCE project, a European FP7 ICT multidisciplinary project that is developing an Adaptive Learning System (ALS) for supporting "poor comprehenders" and their educators (parents and teachers). Poor text comprehenders are about 10 % of young children; they are proficient in word decoding and other low-level cognitive skills, but show problems in deep text comprehension. Experiments show that inference-making questions centered on a number of identified skills, together with adequate visual aids, are pedagogically effective in fostering deep comprehension of stories [2]. However finding stories and educational material appropriate for poor comprehenders is a challenge and the few systems promoting reading interventions are based on high school or university textbooks. TERENCE main objective is to face and solve such issues by developing the first ad hoc ALS, in Italian and in English, for improving the reading comprehension of 7–10 years old poor comprehenders, building upon effective paper-and pencil reading strategies, and framing them into a playful and stimulating pedagogy-driven environment.

The project is now in its final phases and we are able to draw conclusions on the achieved results and on the design experience as a whole. While previous papers focused on specific aspects of the system (like system functionality and architecture [3], models underlying the learning material [1], and usability evaluation [4]), here we focus on the analysis of the context of use by presenting methods and techniques used to classify users—especially the learners—and to elicit requirements (Relevance Cycle) with the twofold objective of (1) turning these considerations into a new inquiry method to enrich the body of knowledge (Rigor Cycle), and (2) discussing how and to which extent their adoption contributed to the successful of the system. In particular we will discuss how the recourse to innovative game-based field studies allowed us both to overcome flaws and limit of existing techniques and to comply with constraints posed by the involved organizations and by project resources and budget.

The remainder of the paper is structured as follows. After reporting in Sect. 2 we report on the two rounds of field studies in TERENCE, in Sect. 3 the game-based user investigation is presented in a structured way. Finally, in Sect. 4, conclusions are drawn.

2 The Field Study in TERENCE

Primary TERENCE users are learners, while secondary users are educators and experts that design learning material, made of stories and games: smart games are used for stimulating inference-making about stories, and relaxing games are used for motivating learners, according to a stimulation pedagogical plan identified by experts. To support the diverse users' tasks TERENCE include modules and interfaces designed according to a UCD approach. The overall design process proceeded iteratively, by applying the following steps for each of the four generations of prototypes/system: (1) analysis of Context of Use and Users' Requirements (CUUR); (2) design of learning material, tasks and GUI prototypes, and (3) evaluation.

CUUR was conducted through a preparatory study followed by two rounds of field studies, in the UK and Italy. The preparatory study and the 1st round of field study of CUUR (May 2010–January 2011) have been the base for the first prototypes. The *preparatory field study* was conducted by brainstorming with about 30 domain experts of text comprehension and HCI, with the main aim of understanding how children are assessed by psychologists as poor comprehenders [14]. The *1st round of CUUR* was based on a combination of traditional user-based and expert-based data gathering methods and involved about 70 educators and 100 learners. It focused on *users*, *tasks* (mainly reading comprehension), and *environment* (physical, instructional, devices), for determining organizational and ethical constraints, main requirements of learning material, and a first cognitive characterization of learners [14].

The main goal of the *2nd round of CUUR* (February 2011–June 2011) was to redefine types of users into classes of users—and defining associated personas—according to requirements relevant for the adaptive engine of the ALS, and its output was the base for the second and the third releases of the system. At this stage some kind of direct interaction with learners was crucial to gather high quality data; furthermore to ensure pedagogical effectiveness of the system, a large-scale study was mandatory. The studies hence involved 2 schools in UK and 5 in Italy, for a total of about 550 learners, aged 7–11, and were run as part of regular school activities.

As experts recommend, data gathering methods cannot be used with children "as is": e.g., children might become anxious at the thought of taking a test and tests may conjure up thoughts of school [7]. Druin suggests using indirect methods [5] and proposes methods that allow working with children as partners according to a co-design approach [6]. There are also examples of co-design at school: e.g., in [16] authors explore the application of co-design methods with children 7–9 aged. However, when situated at school and within school activities co-design has some limitations if it is done with many learners and organizational constraints: for example, in TERENCE, schools imposed that all children of a class had to be involved at the same time and that the timing of data gathering activities had to be below one hour.

On the other hand, theoretical and empirical studies show that learners are more motivated to participate in school-class activities if they are shaped like games (e.g., [11, 12]). In [13] authors overview research findings about the correlations between the appeal of games and the psychological need satisfaction they provide, and propose a motivational model that shows that, besides the basic elements of *move* of the player and *outcomes* showing progresses, at least three factors determine engagement: *autonomy*, amounting to a sense of choice and psychological freedom (e.g., players may choose the level to play or the avatar), *competence*, realized by carefully balancing the game challenges to the players' skill, and *relatedness needs*, i.e., the sense of communion with others, attained by stimulating collaboration or competition.

All this considered, we decided to base on games not only the ALS stimulation plan but also the field study. We designed and experimented an innovative children-oriented data gathering approach based on gameful activities designed according to motivational models. The protocol of game-based activities was checked and assessed with schoolteachers (e.g., if a challenge was deemed too difficult or too boring for a school class, it was revised according to teachers' feedback). Data gathering was organized as 6 different games, each of which structured as an independent game aimed at gathering information on a topic to be investigated (identified during the 1st round of CUUR). There were 2 collaborative games, involving all class learners at the same time, and 4 single-player games. At the start of each game, investigators explained goal and moves for advancing through the game. Autonomy, competence and relatedness needs were pursued across the various games. *Autonomy* was elicited by allowing learners to choose among several options for tackling a challenge or to take the decision to skip it. *Competence* was pursued by stimulating diverse skills across games (e.g., some games required mainly verbal skills whereas others mainly drawing skills). The presence of a investigator working as guidance helped to satisfy *relatedness* needs; in two games these were achieved by stimulating the school class to work together. A framework was created for each game specifying the goals and moves of the game, and how autonomy, competence and relatedness needs are pursued. In Fig. 2 we provide an example of instantiation of the framework for a game associated to a specific topic to be investigated, while in Sects. 3 and 4 we provide a structured description of the method and a discussion on its impact on the success of the project, respectively.

3 Game-Based User Investigation

To formally describe the method we propose, we adopt a presentation structure inspired by the one used by usability.net. Furthermore, for all the techniques cited in the following and we refer to http://www.usabilitynet.org/tools/methods.htm.

Summary The *game-based user investigation* is a children-oriented data gathering method, based on game administration, for discovering facts, opinions

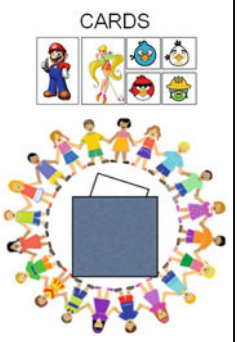
Investigation topic	Gather information about the learners' favorite game characters (useful for designing avatars of TERENCE stimulation plan games).	
Game description	**Goal**. The goal of the challenge is to describe popular video game characters. **Moves**. Each learner has to choose a card from the container. A card depicts a character of a popular console game. The entire class then discusses what they like or dislike about that character.	
Autonomy	Each learner can choose whether to extract the card and participate, or not, in the game; each learner can choose what to tell about the selected character.	
Competence	Each learner can express his own verbal skills.	
Relatedness needs	Each learner can feel part of the class by talking about characters or listening to others' preferences.	

Fig. 2 An example framework instantiation

and behaviors of potential users of the system being designed. Depending on the selected setting (laboratory or real context) it may or may not produce field data. It is preferably done by at least two investigators interacting with individual users or group of users (min 2–max 30 ca.) per session, depending on whether work group is an aspect to be evaluated for the system being designed. During a session, investigators play with users, observe them as they play, take notes on the activities that take place, and possibly record audio/video data. Investigation involves a *direct observation* by investigators actually present during game administration and an *indirect observation* on collected materials (e.g., game results, notes, audio/video recording) by teams including also other investigator. The aim is to gather as much genuine and reliable data as possible.

Benefits This method embodies characteristics from other traditional investigation techniques: as *questionnaires* it allows to gather a high quantity of data in relatively short sessions, as *interviews* it allows a direct interaction with users, as *user observation/field study* it allows to view users in their real context. Anyhow, differently from any other technique, it is based on the administration of specifically designed game-based activities, which introduces a *new kind of interaction with users* in the repertoire of data gathering methods. Due to this specificity, the new method succeeds in offering benefits typical of the above mentioned investigation techniques while overcoming their limitations: compared with questionnaires, it guarantees high quality of data; compared with interviews, it guarantees high quantity of data in short time, compared with user observation/field study, it prevents obtrusiveness since investigators do not interfere with routine activities but rather propose new ones. Furthermore, this method allows investigators to collect a high quantity of structured user-produced data (game results), to be archived for later (statistical) analysis.

Method As in more traditional data gathering techniques, the application of the method requires a sequence of three stages: *planning*, *running,* and *reporting* (see Fig. 3), described in the following subsections.

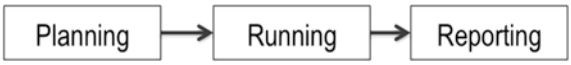


Fig. 3 The overall structure of the method

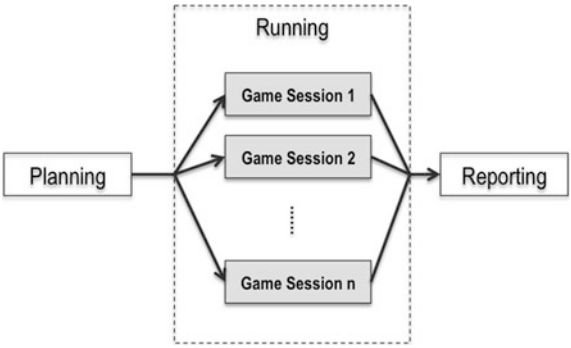


Fig. 4 Focusing on the running stage

3.1 The Planning Stage

The *planning* stage is mainly devoted to designing/realizing the "investigator kit", based on the outcome of a preliminary study necessary to acquire in-depth knowledge on topics/subtopics to be investigated, appropriate language and way of approaching, context constraints. The kit includes games, game materials, customary notes templates, and a database to be populated by data gathered during the running stage. Depending on the established schedule, the running stage may consist of a number of independent game sessions, each based on the same "investigator kit" (see Fig. 4).

The *investigator kit* is designed according to the following requirements:

- there must be a specific game for each specific topic to be investigated;
- the overall set of games has to include games with different cognitive load so that a game session can mirror customary warm-up, peak, and relaxing interview phases;
- topics (and associated games) have to be prioritized according to their relevance to the project in order to be able to shape the individual game session on the fly at running time while maintaining the warm-up/peak/relaxing structure (necessary to adjust the session depending on interrupts and other unpredictable events);
- the estimated duration of a game session should not exceed 45/60 min.
- Design of individual games has to consider a number of factors:
- each specific game must cover all subtopics of the topic it is associated to; these subtopics are the primary inspiration for the creation of the game that, in any case, has to be shaped according to consolidated game frameworks [13];
- mandatory characteristics of individual games are: playfulness, child personal enrichment, compliance with ethical issues;

- each specific game must include a rewarding mechanism, designed so to stimulate the production of genuine data from each child;
- individual games should produce children-generated collectable results (e.g., conceptual maps).

3.2 The Running Stage

As previously discussed and depicted in Fig. 4, the *running* stage may consist of a number of independent game sessions based on the same "investigator kit". Each session includes the four phases of *nurturing*, *motivation*, *body*, and *closing*, according to the structure depicted in Fig. 5.

Nurturing In this phase investigators introduce themselves, explain the aim of the session, and establish a playful atmosphere. It is essential to make clear that the participation to games is free and to be sure that children do not see investigators in negative terms.

Motivation In this phase, techniques from motivational theory [13] are used to ensure a sense of responsibility in the children, essential to get reliable data.

Body In this phase investigators administer games and observe children. Games are selected at run-time from the "investigator kit" according to a flexible plan that takes into account: estimated duration of the games, remaining time, topic coverage, topic priorities, warm-up/peak/relaxing cognitive curve, number of involved children. Each administered game requires the four steps of *energizing*, *playing*, *rewarding* and *reorganizing* giving rise to the overall iterative structure of the body phase in Fig. 6:

- *Energizing* In this step goals, moves, and rewards are introduced and excitement is provoked.
- *Playing* In this step the main *direct observation* takes place: the specific game is administered and investigators keep focus on how children carry on game activities, while stimulating children in maintaining interest and supporting their requests. Investigators try to be aware of influences affecting children, take notes of each behavior interesting for later analysis, and may take photos, audio and video recording of the game areas. If the setting is a real context, field data about operation areas are recorded as well, as a reminder of the environmental context.
- *Rewarding* At the end of the specific game, investigators officially close the game, declare winners for group games (if planned), and deliver prizes.
- *Reorganizing* In this step investigators collect and organize produced material.

Closing For ethical and motivational reasons, at the end of the game session it is important to make sure that each child gets a reward. Furthermore, in this phase investigators reorder collected material and write down first impressions about the experience before the analysis. It is also a good idea to spend some time with secondary stakeholders that attended the game sessions to clarify and solve any doubt.

Fig. 5 The structure of a session

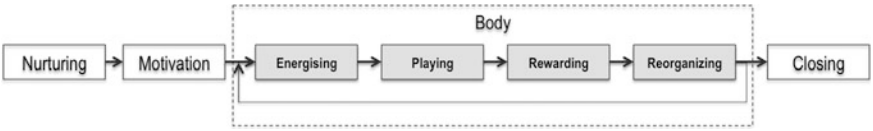


Fig. 6 Focusing on the body structure

3.3 The Reporting Stage

Since the method produces vast amount of high quality data, it is important to analyze them by an *indirect observation*: investigators use collected data to populate the database designed in the planning stage, and conduct statistical analysis to produce user classification, personas design, and requirements specification.

4 Discussion and Conclusions

We discussed some aspects of the design experiences acquired within the TERENCE project that is developing an ALS for supporting poor comprehenders and their educators. We focused on data gathering issues, which, in the case of children, make flaws and limits of traditional methods emerge (e.g., difficulties in involving and motivating users, coping with organizational constraints). The age of learners, along with literature studies on children involvement in school activities, suggested us to explore a game-based approach as primary data gathering method.

The data we gathered were qualitatively genuine (a child could express his/her true self) and dependable for creating fine-grained profiles of learners and their preferences. The reliability of data is supported by evidence from teachers and parents of the involved children (gathered via contextual inquiries). The new approach proved to be definitely engaging for children and teachers, to the point that the involved schools became so interested in the project that volunteered to participate in the prosecution of TERENCE activities (this allowed us to carry on a large scale evaluation with about 900 learners in two countries). The chosen approach also allowed us to conduct an extensive study with many users within time limit and organizational constraints.

On the other hand it has be said that game design and game material constructions require considerable human resources, and that the semi-structuredness of collected data may make their analysis expensive. Notwithstanding these

drawbacks, the attained results and their contribution to the success of the project make it reasonable to study if and how a game based approach can fit in the body of knowledge of UCD contextual studies, since its goals and effects may outbalance some flaws of traditional techniques not only for the new types of users that are entering the realm of technological artifacts, but also for more traditional users.

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