Blending Evidence and Users for TEL: an Overture

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Abstract. TERENCE is an adaptive learning system for reasoning about stories with children having deep text comprehension problems. It develops reading interventions in the form of smart games for stimulating the text comprehension of such children. In order to ensure the pedagogical effectiveness and the usability of the smart games, and of the system in general, TERENCE was designed combining the user centred and the evidence based design. In this paper, we illustrate how such methodologies were used in the design of the TERENCE smart games.

1 Introduction

Developing the capabilities of children to comprehend written texts is key to their development as young adults. From the age of 7–8 until the age of 11, children develop as independent readers. Nowadays, more and more children in that age range turn out to be poor (text) comprehenders: they demonstrate difficulties in deep text comprehension, despite well developed low-level cognitive skills like vocabulary knowledge.

TERENCE is a Collaborative Project funded by the EC under the ICT Call 5 FP7-ICT-2009-5 (1 October 2010-30 September 2013) and aims at designing and developing an intelligent *adaptive learning system* (ALS) with learning material adequate for poor comprehenders [3]. Therefore the types of users of the TERENCE ALS are: *learners*, namely, primary-school poor comprehenders, hearing and deaf, older than 7–8; *educators*, namely, primary-school teachers and support teachers, as well as parents of the TERENCE learners. The learning material of the TERENCE ALS is in English and in Italian. The material is made of stories, collected into books and divided into difficulty levels for the TERENCE learners, and of smart games for each story, centred around inference-making interventions necessary for text comprehension. The main learning tasks of the learners with TERENCE are reading the adequate level of stories and playing with the adequate level of smart games for each story. Reading and playing are organised in cycles according to the stimulation pedagogy plan of TERENCE [5].

The TERENCE system and its learning material are developed following the user-centred design (UCD) [8] and the evidence-based design (EBD) [2]. Generally speaking, the UCD places the user, actively, at the centre of the design process, which is iteratively repeated until attaining the usability of the system. The EBD of a system stresses the need of basing design decisions on empirical evidence, involving experts of the domain in the process. In TERENCE, the UCD and EBD were mixed for analysing the context of use of the system and evaluating incremental versions of the systems.

This paper illustrates how such methodologies were used for iteratively and incrementally developing the TERENCE smart games, starting from the context of use analysis and ending with their evaluations.

The paper sketches the data gathering for setting the requirements for the smart games in Sect. 2 and the resulting design of the TERENCE smart games in Sect. 3. Sect. 4 presents the evaluations with experts or users, and their aims. This paper ends with a recap conclusive section.

2 The Context of Use Analysis for Smart Games

The context of use of TERENCE was analysed for specifying the characteristics of the users, the learning tasks the system should support and environment constraints. In the remainder, we focus on the learning tasks.

The main data for specifying the learning tasks and hence designing the smart games of TERENCE were gathered through

- contextual inquiries with experts of (poor) text comprehension,
- contextual inquiries with educators,
- and game-like field studies with learners.

See [9]. In particular, the data gathered from experts are, mainly, relevant reading interventions and how they should be scheduled for effectively stimulating the text comprehension of the TERENCE learners. For instance, according to the experts responsible for the pedagogy plan of TERENCE, rewards are a valuable mechanism for motivating the learners to continue playing and allow for breaks; relaxing games, stimulating visuo-perceptual skills and not reading comprehension, should have precisely such goals and work as rewarding mechanism after playing with the more demanding smart games. On the other hand, said the domain experts, smart games should be designed like interventions for the analysis of stories [9], supported by adequate visual representations, so as to guide the child to better recall and correlate the information that are acquired reading a story. More precisely, smart games should stimulate reasoning about: the characters and and their participation in the stories; temporal relations between events; causal-temporal relations between events. The interventions selected for the smart games were thus hierarchically organised and scheduled into macro-levels according to their main pedagogical goal:

1. at the entry macro-level, interventions focusing on characters, layered into two levels: who the agent of a story event is (who), what a character does in the story (what);
2. at the second macro-level, interventions focusing on time, layered into four levels: for reasoning about temporal relations between events of the story, purely sequential (before-after) or not (all the others);
3. at the last macro-level, interventions focusing on causality, layered into three levels: the cause of a given event (cause), the effect (effect), or the cause-effect relations between two events (cause-effect).

The TERENCE smart games were then layered into similar levels. The following section sketches how the design of smart games was conducted and based on the requirements established by the domain experts.

3 The TERENCE Smart Game Design

According to [1], a game should specify the following data: the *instructions* and overall *goal* of the game, the *initial state* of the game, the *termination* state, the legal *actions* of the players, and the *maximal duration time* per action if foreseen. For specifying the data for the TERENCE smart games, we analysed the requirements illustrated above. Then we abstracted and structured the data into the TERENCE game framework. The TERENCE framework was then specialised for each game level, e.g., we have a specific framework for all before-after game instances.

The TERENCE game framework is based on similar frameworks found in the literature, e.g., see [6]. However, the TERENCE framework is for puzzle or casual games like in TERENCE, and hence it is more specific and structured, lending itself to the automated generation of textual smart games by mixing constraint-based reasoning and natural language processing technologies, see [4] for an outline of the overall generation process, and [7] for the resulting textual instances of smart games.

The TERENCE framework of each game level was then used to create a related visual template. This was used for designing the interface of each game level, according to the age of the TERENCE learners. The interface design and its evaluation is briefly sketched below.

4 The Evaluations of Smart Games for Usability and Pedagogical Effectiveness

The TERENCE smart games were released in three main versions: the first was released in March 2012; the second was released in June 2012; the third was released in March 2013.

The first version implemented 9 smart game instances, at least one per smart game macro-level—character, time, causality. The prototypes of smart games were evaluated via heuristic evaluations or expert evaluations by experts of text comprehension or of interaction design. One of the main goals of the evaluations was to assess whether the smart games could be pedagogically effective for the TERENCE learners according to experts of text comprehension that were not involved in the context of use analysis. The other main goal was to detect potential usability issues with the graphical user interface with experts of interaction design.

The second version had games for two stories, with circa 12 smart games per story. The games were evaluated with 168 TERENCE learners in order to get pedagogical indications concerning the effectiveness of the TERENCE smart games and detect usability issues for the learners. The data collected were quantitative, e.g., performance metrics on tasks, and qualitative, mainly gathered via observations or interviews.

The third version of the TERENCE system implemented all the TERENCE stories, which are 32 written into 4 levels of difficulty and organised into books. For each story, this version of the system has circa 12 smart games, for a total of more than 380 smart games. This version is currently used in a long-scale evaluation for completing the study of the pedagogical effectiveness of the system and of its usability. The evaluation involves more than 900 learners across Italy and UK; it uses standardised tests of text

comprehension for assessing the pedagogical effectiveness of the system as well as standard measures of usability, like time of tasks.

5 Conclusions

TERENCE is an European project developing an ALS specific for poor comprehenders and their educators, by combining the UCD and EBD methodologies. The project, thus, seeks the constant involvement of the users (poor comprehenders, deaf children and their educators) from schools in the UK and in Italy and domain experts, in particular, of text comprehension. Having both the users and domain experts involved in the context of use analysis and evaluation stages of the project, iteratively, helps to early detect usability and pedagogical effectiveness issues and solve them in time. In this paper, we outlined how the smart games of TERENCE were designed following the UCD and EBD methodologies, starting with the context of use analysis, and stepping through the design of the TERENCE smart games that was iteratively and incrementally refined via evaluations. To the best of our knowledge, TERENCE is the first technology enhanced learning project that combined UCD and EBD in such a manner for attaining the usability and pedagogical effectiveness of its system.

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