80Days: Immersive Digital Educational Games with Adaptive Storytelling

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Abstract. Three major challenges for developing and evaluating immersive digital educational games (DEGs) are identified, including (i) improving adaptive technologies, especially digital storytelling, to shape learning experience; (ii) providing technological approaches to reduce developments costs for DEGs, and (iii) developing robust evaluation methodologies for DEGs. We address these challenges in our R&D project that aims to develop cost-effectively a geography game prototype with pedagogically sound methodological frameworks and advanced technologies, which will be validated with empirical data. In this paper our focus is set on the first two challenges – advances in adaptive digital storytelling and reusability of learning materials.

Keywords: Immersive digital educational games, Marco adaptivity, Micro adaptivity, Digital storytelling, User experience, Reusability, Geography

1. Introduction

Developing digital educational games (DEGs) that can cost-effectively foster learning with fun and pleasure is a *vision* for researchers and practitioners in the field of HCI and technology-enhanced learning (TEL). DEGs offer exciting and dynamic environments which engage players in meaningful and motivating learning activities, inspiring them to explore a variety of topics and tasks. Simulative characteristics of DEGs can contribute substantially to knowledge construction of individual players, and their social aspects can enhance players' collaborative learning skills. Nonetheless, to realize the vision, three major challenges must be dealt with: (i) The large degree of freedom enabled by digital game environments renders it extremely hard to tailor them to users' personal learning experiences and preferences, and to provide users with purposeful and non-invasive advice; (ii) The relatively low competitiveness of DEGs as compared with their commercial counterparts, which attract a huge amount of investment that allows the production of very high quality games to which teenage players are accustomed, raising their high expectations for DEGs; (iii) The lack of well established approaches to yield persuasive evidence about the educational efficacy of DEGs, rendering it hard to get support from parents, educators, and policymakers to incorporate DEGs into regular curricula. The corresponding implications are to refine the development of intelligent and adaptive

educational technologies, to identify technological approaches to reduce the development costs of DEGs, and to identify innovative and robust evaluation methodologies to validate pedagogical models and technological solutions for DEGs.

Our newly launched R&D project - *80Days* (http://www.eightydays.eu/) – aims to address the afore-mentioned challenges. Specifically, we aim to tackle the problem of reducing the costs of developing immersive DEGs by providing a methodological framework, including technical advancements, adaptive and interactive digital storytelling and generic adaptive tutoring methodology (cf. Competence-based Knowledge Space Theory (CbKST) [1]) and by realizing different scenarios on the same base game. Scenarios being deployed in our project are inspired by Jules Verne's appealing novel "*Around the world in eighty days*", in which our project's name is rooted. The prototype topic and the game demonstrator are based on *geography*. The rationale for selecting this discipline is threefold: First, a broad range of sub-topics and knowledge domains provide well-defined internal structures in terms of prerequisites among specific competencies; Second, curricula ranging from primary education to university level facilitate the scalability of the prototype; Third, appealing 2D and 3D learning resources (e.g. cartographic material) can be perfectly utilized for immersive games with motivating narratives.

In this paper we focus on the first two challenges, namely advances in adapative digital storytelling (Section 3) and reusability of learning materials (Section 4). The third challenge – the evaluation framework – is documented elsewhere. Specifically, we describe the associated conceptual frameworks and address the related issues as well as possible resolutions. They will be validated and refined with empirical data to be collected in the course of the project.

2. Background

With the shared view that immersive DEG can make learning engaging, inspiring and presumably effective, enthusiasms and efforts over game-based learning have soared in the recent years (see [2). The major strengths of DEGs include [12] a high level of intrinsic motivation to play and to proceed in the game; clear goals and rules; a meaningful yet rich and appealing learning context; an engaging storyline with random elements of surprise; immediate feedback; a high level of interactivity, challenge and competition. These characteristics are compatible with Merrill's [11] odel for successful learning. Nevertheless, DEGs have some drawbacks such as difficulties in providing an appropriate balance between gaming and learning activities or between challenge and ability, in aligning the game with national curricula, and in affording extensive costs of developing high quality games. Besides, the lack of sound instructional models is seen a common weakness of most educational games, leading to separation of learning from gaming.

Nevertheless, commercial computer games are tremendously successful and game industry constantly increases sales to several billions of euros. A large number of youngsters spend many hours a week playing games. These observations corroborate the presumption that utilizing gaming activities for educational purposes and

exploiting the educational potential of computer games is a highly promising approach to facilitate learning by making it enjoyable and pleasant.

The project 80Days is built upon the results of its predecessor ELEKTRA [3] which has made significant contributions to advancing the state-of-the-art of competitive DEGs in terms of educational game design, integration of pedagogical models and taxonomies, and personalization by adaptive technology. Pedagogically, 80Days is grounded in the framework of self-regulated personalized learning (SRPL) [5] which propagates the importance of self-regulation through mindful and meaningful choice and exploration, reflection, and self-personalization in the learning process. It contributes towards the creation and sustainability of intrinsic motivation, a key factor of effective game-based learning.

3. Advances in Adaptive Digital Storytelling

Individualization of learning experiences and adaptation to personal aims, needs, abilities and prerequisites entail in-depth understandings of individual learners and their behaviour with a DEG. It is critical *not* to destroy the immersion and gaming experience by intervening knowledge assessments, which are commonly used in traditional approaches to adaptive educational technologies that focus on knowledge and learning progress. In contrast, DEGs take into account a broader scope of issues such as individual preferences (e.g. visual styles or gaming genre). Prevailing cognitive models for adaptive educational technologies (which are primarily competence-based) should thus be merged with theories of achievement motivation and models of interactive and adaptive storytelling to establish a comprehensive theoretical framework for combining learning and gaming.

Techniques of adaptation and individualization are essentially *adaptive presentation*, *adaptive navigation support* and *adaptive problem solving*. In the framework of ELEKTRA [3] a new terminology was introduced, basically because of the reason that game-based approaches to learning are substantially different from traditional approaches to e-learning. The new concepts, which are tailored to learning environments with large degrees of freedom, are adaptively on *macro* and *micro* levels ([6]; Fig. 1). Macro-adaptivity refers to traditional techniques of adaptation such as adaptive presentation and adaptive navigation on the level of learning objects (LOs) (or learning situations (LeSs) in a DEG). Generally, macro-adaptive interventions are based on a fixed learner model (e.g., traits) or adaptation model (e.g., pedagogical implications) and on typical (knowledge) assessments (via test items). Micro-adaptive interventions, on the other hand, are non-invasive (meaning that an overall narrative is not compromised) and affect the presentation of a specific LO or LeS.

Existing approaches to adaptive educational technology are deemed inappropriate for gaming learning environment, because within a DEG learning tasks are intricately embedded in the game's narrative. Reordering of learning tasks would result in a, most probably, implausible rearrangement of the narrative plot elements. Due to the nature of immersive DEGs the adaptation within such games needs to be continuous and less periodic; it needs to occur more frequently than on a task by task level. This

issue can be resolved by integrating micro-adaptivity into the environment, where adaptation occurs *within* the various learning situations as opposed to *around* them. Micro-adaptivity creates challenges of its own due to the nature of the experience of game play, and the impact that game world changes can have on a player's experience.

To drive the (r)evolution of cognitive and psycho-pedagogically inspired frameworks for purposeful adaptive interventions, it is imperative to extend the existing state-of-the-art by integrating motivational and emotional aspects, adaptive storytelling, and dynamic processes of learning and navigation (cf. [6]) into a sound cognitive framework, i.e., a dynamic three-component framework for adaptive interventions and probabilistic knowledge assessments. In contrast to existing approaches, which separate learner, domain and adaptation models, this framework is based on a holistic understanding as well as a formal ontological representation of interacting processes involved in active and dynamic learning processes (Fig. 2).

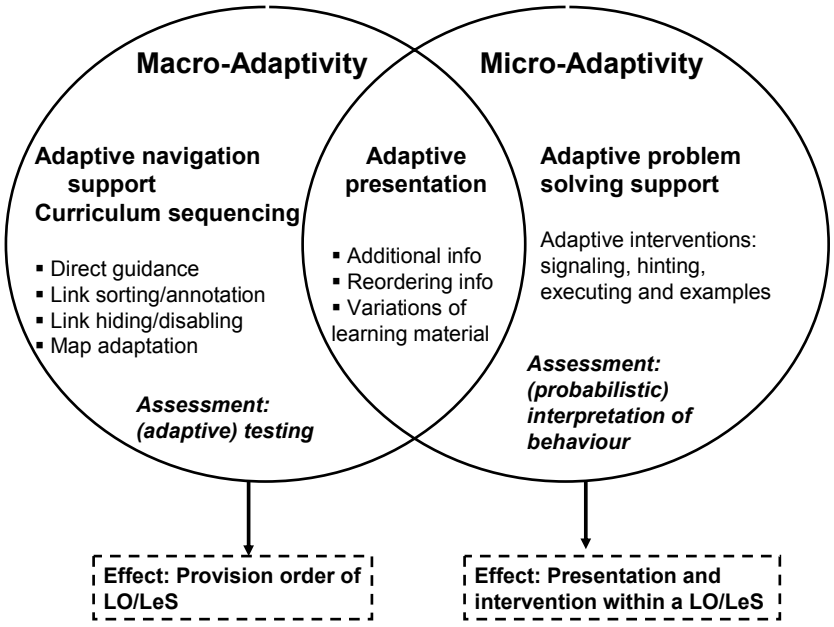

Fig. 1. Macro- and micro-adaptive techniques
(NB: LO = Learning Object; LeS = Learning Situation)

Integrating adaptive storytelling with gaming activities can lead to motivating and compelling learning environments (Fig. 2). Early story generation systems relied on non-dynamic models of narrative. The first story generation systems were implemented based on Brenda Laurel's [7] vision of interactive drama, (see e.g. [14], [8]). While the most effective drama models developed for feature films have become global professional standards (e.g. [13], [10]), very few drama models developed for screenwriting have yet been integrated in story generation systems.

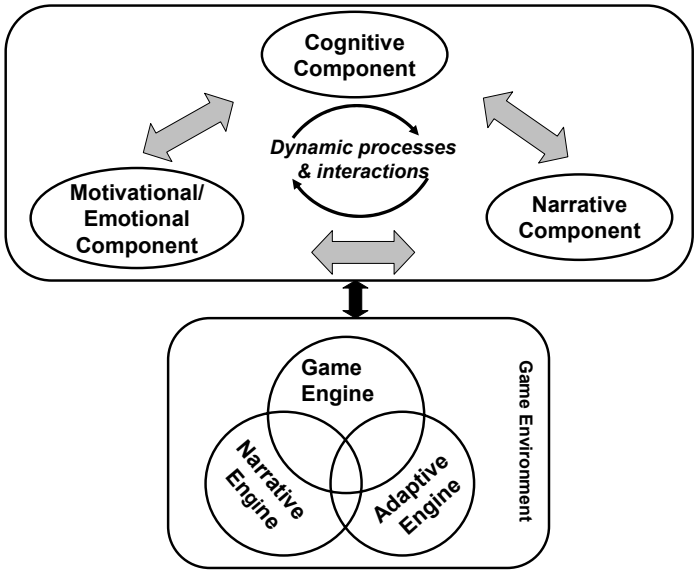

Fig. 2. A dynamic model of an adaptive gaming environment

The challenge of creating dynamic and plausible adaptive narratives is enormous and entails laborious manual editing of branching narratives. The difficulties of creating adaptive narratives can well be exemplified by experimental systems such as *Façade* [9] or *Virtual Human* [4]. Specifically, 80Days aims to establish a theoretical basis for generic but engaging, immersive and plausible storytelling in educational games. More importantly, 80Days will merge this theoretical basis with cognitive and motivational/emotional aspects of dynamic learning processes (see Fig. 1 & Fig. 2). References will be made to the related projects such as E-CIRCUS (http://www.e-circus, org) that works on virtual role-play with synthetic characters establishing credible and empathetic relations with learners, and VICTEC (http://www.victec.net) that works on applying synthetic characters and emergent narrative to personal and social education for children 8-12.

4 Reusability of Learning Materials

In a DEG, adaptive and interactive digital storytelling serves two essential purposes: First, it strongly supports a personalized learning experience by adapting the game's story to individual preferences and by providing the possibility of explorative learning processes. Second, it serves the re-usability of learning material by enabling the realization of different stories and entirely different games, also for a variety of different learning domains based on more or less the same pool of story units, patterns and structures as well as learning and gaming concepts and elements/objects. Furthermore, re-using learning material contributes to minimizing costs, particularly with regard to the design of documents.

The development of competitive DEGs is cost-intensive, and the markets are narrow because DEGs may relate to limited age groups or specific curricula. Thus, the integration of existing learning resources is a crucial aspect of efficient and cost-effective learning design and game development. The integration of external resources (e.g., learning media, websites, web services, 3D material, or cartographic material) with a game engine into a coherent and immersive game environment is difficult. Since the development and application of immersive DEGs is still at an early stage, to date no appropriate methodologies exist which enable an effective integration of existing learning resources and their (re)use in DEGs. Hence, it is deemed critical to analyze the technological and didactic demands and mutual dependencies between learning resources, learning activities, pedagogical models, and narrative/game engines. An approach of resource harmonization, resource symbolization, and ontological resource description, should also be established.

5. Concluding Remarks

Exploiting up-to-date 3D computer games for educational purposes is a dawning technology but still in its fledgling stage. It is one of the challenges to be addressed in 80Days, which also aims at augmenting and integrating the related theoretical frameworks in cognitive psychology. Exploiting the desirable features of digital games to be effective learning tools entails well-orchestrated efforts of a highly interdisciplinary team to tackle the three major challenges addressed above. Concrete empirical results will be documented in the near future.

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