An Educational Guide to Planet Earth: Adaptation and Personalization in Immersive Educational Games

Michael D. Kickmeier-Rust, Elke Mattheiss, and Dietrich Albert

Department of Psychology, University of Graz
Universitaetsplatz 2, 8010 Graz, Austria
{michael.kickmeier; elke.mattheiss; dietrich.albert}@uni-graz.at

Abstract. Using computer games for educational purposes is a fascinating and popular idea. An important goal of research is an increased personalization and adaptation. In the present work we introduce the work of the 80Days project which primarily focuses on non-invasive in-game assessment and adaptation on the basis of psycho-pedagogical models. Moreover, we present the manifestation of research efforts in form of a compelling demonstrator game.

Keywords: Digital educational games, game-based learning, adaptation, personalization, interactive storytelling

1   Introduction

Computer games potentially serve as an important technological tool to support educational aims. This is common sense amongst most researchers in this area and justified by the current hype over game-based learning. To some degree, the idea can be traced back to 1980, when Seymour Papert [1] published his famous book *Mindstorms*, within which he argued that the rich possibilities computers shall be used to facilitate and promote education; he argued that the future of education lies in working on real problems instead of learning basic skills and pure facts in a dull way. Today, there is a vast amount of examples for educational games, ranging from so-called moddings (modifications of commercial, non-educational games) to appealing games and simulations for primarily educational purposes.

The reason for the popularity of digital educational games (DEGs) is not only the appeal of computer games to young people in general, computer games enable realizing elementary and essential pedagogical and didactical principles in a very natural way. The game environments and experiences, including strong competitive elements, serve as a means of making learning and knowledge important and meaningful for the learners. Similar to collecting items and/or scoring in regular games, collecting the knowledge and skills is the key driver of gaming and learning activities. Learning occurs in a meaningful context and learning performance translates directly to a plausible immediate feedback.

In this paper we briefly introduce aspects of the work of the *80Days* project (*www.eightydays.eu*), which addresses the evolution of DEGs primarily from the axis

of intelligent personalization - concretely, a psycho-pedagogical framework that enables a non-invasive assessment of cognitive as well as motivational states and a corresponding non-invasive adaptation/personalization by system responses and global alterations of the game. What we propose is an intelligent technology that allows an adaptation to individual learners, their prior knowledge, abilities, preferences, needs and aims. By this means the learner will have optimal motivation to play and therefore to learn, because s/he is perfectly challenged, and neither overburdened by too difficult gaming and learning activities, nor bored by too simple ones. Finally, we introduce a manifestation of our ideas of adaptive educational game technology in form of a compelling demonstrator game and we give an outlook to future aspects of the project's work.

2   Intelligent Adaptation in Rich Game Worlds

In the first instance, intelligent adaptation means meeting the requirements, goals, needs, and preferences of the learner – in an educational sense as well as in a gaming-related sense. Such adaptation, of course, demands a very in-depth basis of knowledge about the learner, the learning progress, the domain, the game, and the available menu of possible interventions and, therefore, sophisticated approaches to assessment.

2.1   Assessment

In conventional technology-enhanced learning, the data basis for adaptation is most often querying the learner, asking for preferences, or providing typical test items for assessing the user's knowledge and learning progress. However, these procedures are not suitable for digital educational games since typical methods of assessment would seriously destroy immersion and flow and, consequently, also the gaming and learning processes. For this reason, we have developed a theoretical model to assess aspects such as knowledge, learning progress, psycho-pedagogical aspects in a non-invasive way. The core idea of the model is to avoid any queries or interruptions but to monitor the learner's behaviour in a gaming situation.

Knowledge/learning progress is assed by associating possible actions of the learner in the game world with specific sets of available and unavailable atomic units of knowledge, that is, skills or competencies. In a probabilistic fashion, the observations and interpretations of actions on a continuous basis steadily increases the quality of the learner model. This concept, labelled micro adaptivity, is described in detail for example by [2] or [3].

Motivational states play a crucial role for successful gaming. Thus, it is highly important to monitor the extent of motivation and intervene if necessary. This, however, is a very delicate attempt. Misdirected or incorrect interventions likely harm the motivational state (probably more than giving no interventions). The existing psychological theories of motivation have been synthesized in order to derive implications for educational game design. Prominent concepts and theories in motivation psychology, like the *flow experience* [4], the *ARCS* model [5] and the *expanded cognitive model of motivation to learn* [6] were formalized and associated

with specific behavioural patterns; this includes action latencies, action frequencies, or specific types of actions (e.g., attempting very difficult tasks as an indicator for high achievement motivation). As it was for knowledge, the game progress and the learner's actions are continuously monitored and, if the system concludes a decreasing motivational state, interventions are triggered to increase motivation again. The results and conclusions by the non-invasive (micro adaptive) assessment, of course, must lead to appropriate and suitable responses by the system. These responses can occur on the micro level (altering the current game situation) and the macro level (apply global changes to the game path) and must be reasonably and sensibly embedded in the game.

2.2 Interventions

On the micro level, a two-fold line of adaptive interventions has been commenced, addressing the educational aspects on the one hand and the learners' motivation on the other hand. Cognitive interventions (e.g., hinting or feedback) are utilized to facilitate and deepen the learning process as well as to strengthen reflective and meta-cognitive abilities. Motivational interventions (cheer, praise, solace, demands, or causal attributions), in turn, are utilized to maintain a suitable motivational level. The conditions under which a certain adaptive intervention is given are developed on the basis of pedagogical rules; however, these rules apply the micro adaptivity framework and utilize the learner model obtained through the assessment within the framework.

On the macro level, the entire game experience can be adjusted, including the game play, the game pace (e.g., by variable time pressure), or the story line. The basic idea is to enable adaptation strategies such as curriculum sequencing. The story model underlying our approach relies on a formalization of the classical three-act structure of *Aristotle* providing an arc model with 'exposition', 'rising action to climax' and 'denouement'. The related set of rules is supplemented with domain-related rules, defining the set of educationally meaningful sequences of learning, so-called *learning paths* through the learning situations of the game. This combination generates *game paths*, possible and meaningful paths through the game accounting for story model, learning objectives, and pedagogical interventions (see [7] for details).
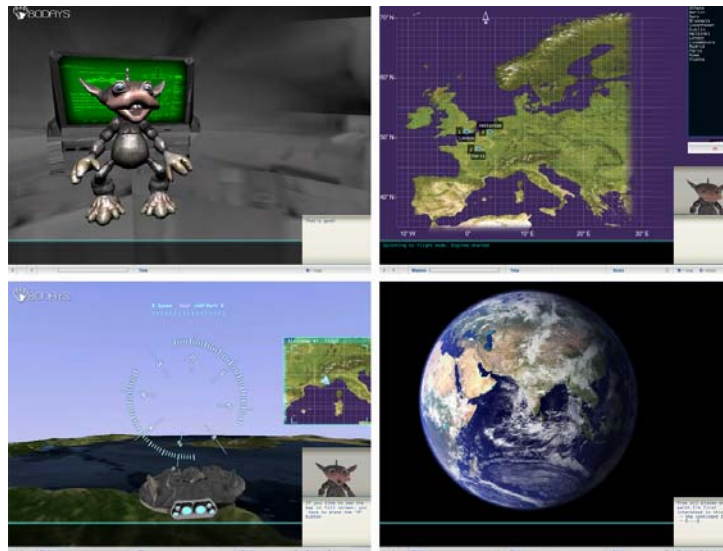
3 The Demonstrator Game

In 80Days, the research activities directly feed the development of a demonstrator game. We have developed an adventure game supposed to teach geography for the age group of 12 to 14 years. The curriculum includes, for example, knowledge about the planet Earth such countries or cities but also aspects such as longitude or latitude.

In the game the learner takes the role of an Earth kid at the age of 14. The game starts when a space ship is landing in the backyard and an alien named Feon is contacting the player. Feon is an alien scout who has to collect information about Earth. The player wants to have fun by flying a space ship and in the story pretends to be an expert in the planet earth. He or she assists the alien to explore the planet and to create a report about the Earth and its geographical features. This is accomplished by

the player by means of flying to different destinations on Earth, exploring them, and collecting and acquiring geographical knowledge. The goal is to send the Earth report as a sort of travelogue about Earth to Feon's mother ship. Finally, the player sees through the alien's game (of preparing the conquest of the earth) and reveals the "real" goal of the game: The player has to save the planet and the only way to do it is to draw the right conclusion from the traitorous Earth report. Therefore the game play has got two main goals: (1) to help the alien to complete the geographical Earth report, and (2) to save the planet, which is revealed in the course of the story, when the player realizes the true intention of the alien.

The game is based on the idea that the real world is the playground where real geographical knowledge is learned. Gameplay and story are based on the metaphor of a "long zoom", which enables to approach geography and the Earth from different perspectives (i.e., a global view of the entire planet, a medium view of countries, cities, and landscapes, and a local view). The actual subject matter is enriched by meta-aspects such as environmental preservation.

Fig. 1. Screenshots from 80Days' demonstrator game.

4   Conclusion and Outlook

The aim of micro and macro level adaptivity – and in parts of the 80Days project – is to enable an assessment of learning progress and motivational states in an educational game without compromising the game's flow. Moreover, the aim is to support the learner with psycho-pedagogical interventions in form of hints, suggestions, warnings, or feedback as well as adjusting the entire game experience including the storyline to the learner's needs, goals and preferences. The probabilistic assessment described here is not perfect, still it slowly increasing the system's view of the learner

in a sufficiently meaningful way. On the basis of this assessment, non-invasive adaptive interventions can be triggered in order to support the learning process. Future efforts within 80Days will improve the assessment procedures and research on the impact of different types of interventions – educationally as well as motivationally.

The demonstrator game and its adaptive features were subject of evaluation activities in Austria, Germany, and the UK. Empirical findings yielded beneficial effect of playing the adaptive game, as evident and an overall satisfying usability and user experience. Implications for the future development of the game prototypes and the design of evaluative activities have been drawn. In particular, the theoretical knowledge and practical experience thus gained will contribute to advancing the research area of evaluating usability and user experience in digital educational games. Future evaluation efforts will focus on a more qualitative approach to evaluation and also on a participatory design approach.

Acknowledgements

References

1. Papert, S. (1980). *Mindstorms. Children, Computer and Powerful Ideas*. New York: Basic Books, New York.
2. Conlan, O., Hampson, C., Peirce, N., & Kickmeier-Rust, M. D. (2008). Realtime Knowledge Space Skill Assessment for Personalized Digital Educational Games. In Proceedings of the *Ninth IEEE International Conference on Advanced Learning Technologies* (ICALT'09), July 14-18, 2009, Riga, Latvia.
3. Kickmeier-Rust, M. D., Hockemeyer, C., Albert, D., & Augustin, T. (2008). Micro adaptive, non-invassive assessment in educational games. In M. Eisenberg, Kinshuk, M. Chang, & R. McGreal (Eds.), Proceedings of the second *IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning* (pp. 135-138), November 17-19, 2008, Banff, Canada.
4. Csikszentmihalyi, M. (1992*). Flow - the psychology of optimal experience*. Stuttgart: Klett-Cotta.
5. Keller, J. M. (1987). Development and use of the ARCS model of motivational design. *Journal of Instructional Development*, 10(3), 2-10.
6. Heckhausen, J., & Heckhausen, H. (2006). Motivation und Handeln: Einführung und Überblick [Motivation and action: Introduction and overlook]. In J. Heckhausen & H. Heckhausen (Eds.) *Motivation und Handeln [Motivation and Action]* (p. 1-8). Heidelberg: Springer Verlag.
7. Kickmeier-Rust, M. D:, Göbel, S., & Albert, D. (2008). 80Days: Melding adaptive educational technology and adaptive and interactive storytelling in digital educational games. In R. Klamma, N. Sharda, B. Fernández-Manjòn, H. Kosch, & M. Spaniol (Eds.), Proceedings of the *First International Workshop on Story-Telling and Educational Games* (STEG'08) - The power of narration and imagination in technology enhanced learning, September 18-19, 2008, Maastricht, The Netherlands.