Narrative Game-based Learning Objects for Story-based Digital Educational Games

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Abstract. This paper introduces the concept of Narrative Game-based Learning Objects (NGLOBs) as the basis for the creation and control of Story-based Digital Educational Games (DEGs). In the context of the European research project 80Days, section 1 describes major aims and challenges of Story-based DEGs and motivates for the introduction and use of NGLOBs. In the main part, section 2 provides an overview of the conceptualization of NGLOBs and their formalization within ICML as an XML-based format for Story-based applications and DEGs. In section 3 the theoretical results are set in context to the 80Days approach. Finally, the main results are summarized and further research activities are outlined.

Keywords: Digital Educational Games, Interactive Digital Storytelling, Technology-Enhanced Learning, Narrative Game-based Learning Objects.

1 Motivation

The overall aim of the European research project 80Days[1] situated in the field of Technology-enhanced Learning is to combine adaptive learning, storytelling and gaming technology in order to build intelligent, adaptive and exciting learning environments in the form of a Story-based DEG.

Hereby, the major challenge is to harmonize the different characteristics and objectives of the storytelling, learning and gaming approaches. In simple words, key aspects and aims of these approaches might be summarized as:

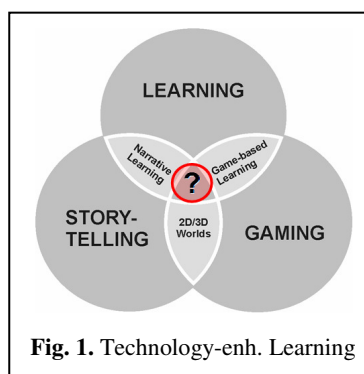- Storytelling: Use of stories as instruments for suspenseful knowledge transfer.

Fig. 1. Technology-enh. Learning

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[1] 80Days – Around an Inspiring Virtual Learning World in Eighty Days. EU, FP7, IST, STREP, Challenge 4.1.2 Technology-enhanced Learning. www.eightydays.eu

Keywords include dramaturgy, suspense or emotion and immersion.

- Gaming: Provision of a playful learning environment. As a slogan *'Learning by playing'* might serve. Fun, motivation, exploration and interaction are dominant.

- Learning: Most relevant is the knowledge transfer. Emphasis is set on assessment, learning success and effectiveness or methodic-didactic aspects. Mechanisms to motivate and engage users are welcome.

In major parts, these aspects and characteristics are complementary, for instance both storytelling and gaming concepts are used to increase the motivation of users in digital educational games. On the other hand –especially with respect to a technical implementation and integration of the concepts– the so-called "narrative paradox" [15] indicates a conflict between storytelling (narratology; linear, non-interactive, plot-based approach) and gaming (ludology; interaction, non-linear gaming approach). Consequently, the role of the author is different: Whereby in storytelling approaches the author has full control over the DEG run-time scenario (everything is pre-scripted, no interaction, no choice to choose among learning paths → *'aura of the author'*), in gaming approaches the player more or less has full control and decides how a Story-based DEG continues (the story evolves during gameplay → *'emergent narrative'* [14, 16]).
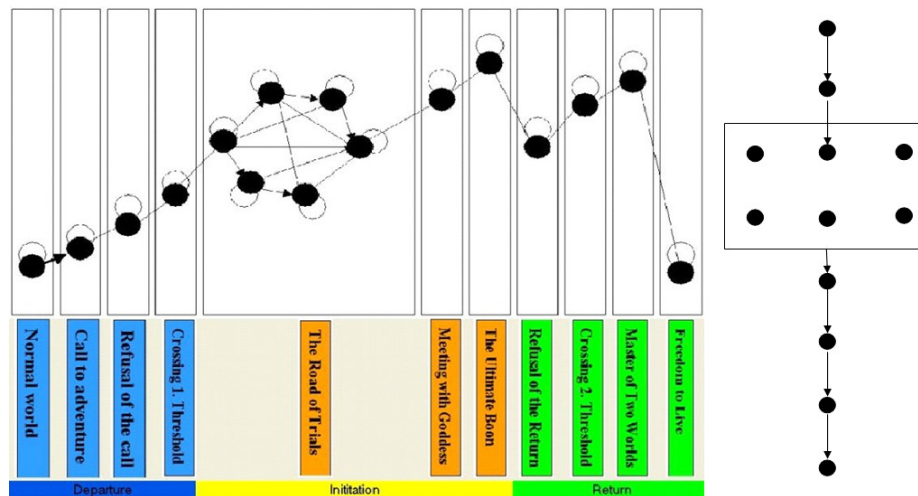

Fig. 2. Hero's Journey story model (left) – linear and modular story units (right).

From a storytelling perspective the narrative paradox and the question how a Story-based DEG continues during run-time (→ macro adaptation, sequencing) has been at the core of the research within the first period of the 80Days project and previous work of the authors of this paper [12, 13]. As the outcome of comprehensive analytic studies and conceptual work, a compromise between plot-based storytelling and non-linear, interactive gaming approaches has been identified [6, 7] and builds the conceptual basis for the overall story structure of 80Days´ demonstrator 1: The Hero's

Journey [3, 17] which is well-proven especially in the domain of adventure games, is used as the underlying (in major parts linear) story model in order to 'guarantee' a suspenseful story. Hereby, the middle part with the dramatic step 'The Road of Trials' is very flexible and provides the possibility to integrate as many story units (→ so-called 'micro missions' in 80Days – similar to levels in a DEG) as the author wishes. Then, during run-time, the story and sequence of micro missions evolves based on the player interaction respectively a mixture of a) pre-defined rules by the author, b) player/learner model and c) learning, gaming and storytelling context.

For that, the main questions are '*How to formalise that multi-faceted context?*' and '*What makes a narrative, game-based learning object (NGLOB)?*'

The following sections of this paper concentrate on the conceptualisation of NGLOBs and their use to create and control Story-based DEGs. The definition and consideration of player/learner/user models as well as (micro) adaptation using NGLOBs according to learner/user/player preferences are not part of this paper, but a topic of ongoing research within the 80Days approach at the Serious Gaming group at TU Darmstadt.

2 Conceptualization of Narrative Game-based Learning Objects

In a first step, based on examples of the game design document (GDD) for the first demonstrator of the 80Days approach, the formalization of narrative, gaming and learning objects is briefly discussed, before an integrated model and its technical implementation in form of an XML-based schema is introduced.
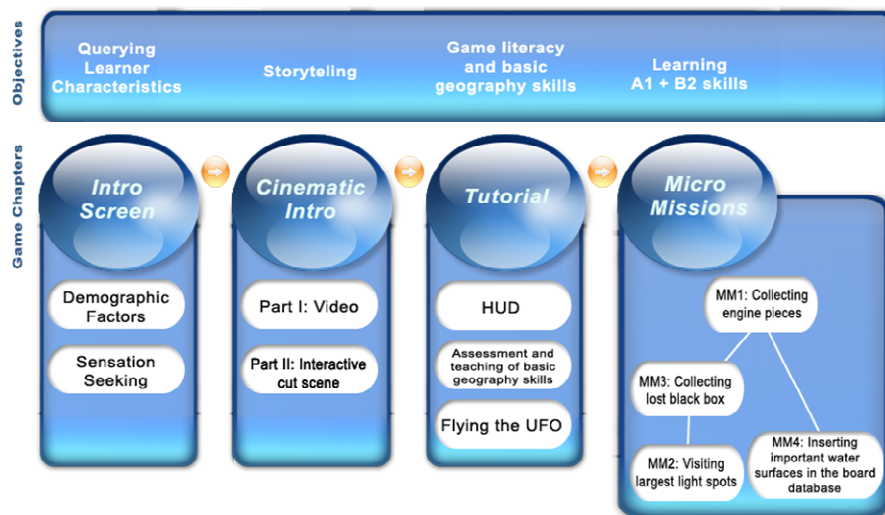

Fig. 3. Story Structure of 80Days´ demonstrator 1. Source: Uni Graz.

More or less following the story model of the Hero's Journey described above the overall story structure of 80Days consists of story units: An *Intro Screen* with pre-

assessment to categorize players/users, a *Cinematic Intro* to initiate the story – corresponding to the first part 'Departure' of the Hero's Journey, an *Interactive Tutorial* introducing the topic and providing information about the gameplay – which might be understood as 'Crossing 1st Threshold' and the micro missions *MM1* to *MM4* representing different game levels or quests – referring to 'The Road of Trials' in the middle part of the Hero's Journey. Each micro mission or the Cinematic Intro provides a unique ID and a short description/synopsis, optionally a visual representation (e.g. a sketch) and is split into storytelling (StS), learning (LeS) and gaming/gameplay situations (GpS) on a narrower level.

Game Chapter	Cinematric Intro				
Situation	*Short description*	*Picture*	*Function for Story*	*Function for Learning*	*Function for Gameplay*
CI_scene 1	We see the original NASA film footage of the Apollo 8 mission..		Create the beginning of a mystery story; set the mood and frame of the story..	This is a visual metaphor for our philosophy for teaching Geography..	--

Table 1. Extract out of the GDD for the Cinematic Intro of 80Days´ demonstrator 1.

The situations themselves vary in their emphasis on either one specific context (e.g. a pure story-driven situation without any gameplay and minor/no learning effects, see situation CI_scene1 in table 1) or a combination of contexts (e.g. LeS 1.3 as game-based learning situation, see table 2).

Game Chapter	Learning Unit 1 (LU1): B2 Skills European Capitals & Countries				
Situation	*Short description*	*Function for Story*	*Function for Learning*	*Function for Gameplay*
LeS 1.1 Pre-test of existing knowledge	Alien asks boy: "You know what cities are these?" The boy now can link illuminated spots and city names on a desk. ..	Now, Mr. Jackanapes has to struggle a first time to keep up his blarney of being an all-knowing earthling.	Reflection on and pre-test of existing knowledge without immediate feedback. ..	Introduction: Game play mode "Global view/Map desk" in simplified 2D view.
LeS 1.3 Position of cities without known names	The gamer can fly above Europe in the UFO and the 2D night map in the HUD gives him his precise position and supports him in deciding to which city (light spot) he wants to fly next.		The player can freely explore Europe while having the learning goals on a map in front of him (cities shown as light spots).	To verify the cities´ names the player has to fly there and to stay paused above them (logging).

Table 2. Extract out of the GDD for Learning Unit 1 of 80Days´ demonstrator 1.

In summary, that kind of style for a GDD might be useful for authors and serve as compact storyboard, but from a technical point of view the problem is the lack of quantifiable information being necessary to be interpreted and processed by computer systems – e.g. in order to determine whether a situation is appropriate to fulfill a specific dramaturgic step within the story model of the Hero's Journey or not.

Therefore, a major aspect during the conceptualization of NGLOBs has been set on the integration of measurable, quantitative and qualitative elements and annotations of narrative, gaming and learning contexts.

2.1 Narrative, Learning and Gaming Context

From a storytelling perspective, narrative objects (NOBs) represent the smallest, atomic units of a Story-based DEG. In 80Days, NOBs are implemented as storytelling situations and technically implemented as cut scenes (without any interaction) or as speech acts and additional actions of virtual characters (animations, gestures, etc.).

For the formalization of NOBs and narrative contexts, the idea is –as far as applicable– to map and annotate NOBs corresponding to the steps and dramaturgic functions of underlying story models such as the Hero's Journey.

With respect to learning issues, formal models for learning objects (LOBs) and their use within courseware (Computer and Web-based Training) have been researched for a long time in the field of E-Learning (for instance with a focus on data storage [11]) and standards are already available: While SCORM[2] focuses on the definition of the overall structure of online courses and provides mechanisms for sequencing LOBs (part 'Sequencing and Navigation', available since version SCORM 2004), LOM[3] provides a set of metadata elements for the description of LOBs and to facilitate search, evaluation, acquisition, and use of LOBs.

For the conceptualisation and formalization of LOBs in the context of Story-based DEGs it is not the aim to rebuild the LOM standard. Contrary, the approach is to use existing learning resources and to reference them within the content section of the overall story format ICML (see section 2.2). Additionally, the idea is to formalize the learning and learner context and to provide machine-readable information about associated and prerequisite skills of a LOBs respectively learning situation based on the Competency-based Knowledge Space Theory (CbKST) provided by Albert and Lukas [1]. Thus, for sequencing purposes –presumed an open, modular, emergent (narrative) environment is available without hardcoded transitions as in pure linear approaches (see section 1)– it is possible to decide whether a learning situation is appropriate for a specific learner (the learner has the prerequisite skills) or not (the learner would be overstrained).

Contrary to the learning context, unfortunately, there are no well-known, elaborated definitions, standards or formats for the gaming context and gaming objects (GOBs). Though, different generic descriptions of games à la '*What makes a good game?*' indicate relevant characteristics and criteria: Apart from graphic and audio/sound, especially gameplay, interaction concepts and a good story decide about

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[2] SCORM: Sharable Content Object Reference Model, www.adlnet.org/Technologies/scorm
[3] Learning Object Metadata, http://ltsc.ieee.org/wg12/

success or failure of a game. With respect to the formalization of NGLOBs and their use in educational games, the interaction concept in form of interaction templates (e.g. drag-and-drop, multiple-choice and puzzle templates in classic courseware or an explorative 3D environment such as a flight mission in 80Days) provides useful attributive information.

Second, similar to the learning context, the idea is to build a correlation between gaming situations/GOBs and the users (i.e. players in the gaming context) and underlying player models. Hence, all gaming situations are set into context with player types and annotated with appropriateness factors.

2.2 Model and Technical Implementation of NGLOBs

In sum, the model for a NGLOB ($\approx$ situation in 80Days) is built by a composition of context information resulting in a triple vector C_N x C_G x C_L.

The narrative context C_N provides a list of tuples (`storymodelStep`, `appropriatenessFactor`) whereby the `storymodelStep` is encoded by the initials of a storymodel (for instance 'HJ' for Hero's Journey) plus a number for the step/part of that model. The parameter `appropriatenessFactor` is normalized in the range [0..1].

The gaming context C_G primarily tackles the appropriateness of individual GOBs and gaming situations for different players and player types. Analogue to the narrative context C_N, the gaming context C_G also provides a list of tuples (`playerAttribute`, `appropriatenessFactor`). Here, 'PA_B$_x$' describes the player type based on the classification of Bartle [2]. For example, 'PA_B1, 0.9' indicates that the GOB is very appropriate for the player type 'Explorer' according to Bartle.

The model for the learning context C_L provides a vector composed out of two parts listing all associated and prerequisite skills for a specific learning situation/LOB. In the example, 'A1$_{xyz}$' and 'B2$_{xyz}$' skills represent identifiers for learning topics of the 80Days´ demonstrator 1 DEG being extracted out of the curriculum for teaching geography in the 6th to 8th grade at school.

$$\left(\left\langle \begin{array}{c} (HJ\_2, 0.1), \\ (HJ\_4, 0), \\ (HJ\_4\_1, 0.2), \\ (HJ\_5, 0.85), \\ \vdots \end{array} \right\rangle, \left\langle \begin{array}{c} (PA\_B1, 0.15), \\ (PA\_B2, 0.4), \\ (PA\_B3, 0.2), \\ (PA\_B4, 0.9) \end{array} \right\rangle, \left(\begin{array}{c} \langle A1030, A1033 \rangle \\ \langle B2122, B2297 \rangle \end{array} \right) \right)$$

Fig. 4. Quantifiable part of the model for Narrative, Game-based Learning Objects.

Apart from that quantifiable part described above, the model for NGLOBs contains further descriptive elements such as short texts/abstracts summarizing the synopsis of narrative, gaming and learning functions of a specific NGLOB.

Figure 5 provides the preliminary technical implementation of the NGLOB model in form of an XML-based schema, which has been integrated into the ICML format.

ICML (INSCAPE Markup Language) has been originated by the authors of this paper within the European research project INSCAPE[4] [5] and used and further cultivated in other projects such as U-CREATE[5] [10] or 80Days. In brief, the global aim of ICML is to provide a standardized comprehensive description language for Story-based DEGs and *any* kind of Interactive Storytelling application. The ICML format [8] provides three top-level nodes: ICML_content, ICML_strategies and ICML_story. The model of NGLOBs is being integrated and serves as detailed annotation and specification of ICML_story parts (complex scenes, scenes ~ micro missions and situations in 80Days or game levels/learning chapters and game situations/learning units in games/learning applications).

Fig. 5. XML-based Schema for NGLOBs, being integrated within ICML_story

3 Narrative Game-based Learning Objects in 80Days

This section describes the creation and use of NGLOBs in 80Days. Hereby, the StoryTec platform providing a complete framework consisting of an authoring tool and a run-time environment serves as technical basis. In [8, 9], Göbel et al. provide a

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[4] INSCAPE: Interactive Storytelling for Creative People (FP6, IP, IST-2004-004150), http://www.inscapers.com
[5] U-CREATE: Creative Authoring Tools for Edutainment Applications (EU CRAFT, COOP-CT-2005-017683)

comprehensive description of StoryTec. In 80Days, the authoring tool and the Story Engine are used and integrated into the 80Days framework.

In order to use NGLOBs in Story-based DEGs such as 80Days, StoryTec has been enhanced both in the authoring tool and run-time components: In the authoring tool, the Property Editor provides fields to enter context information of a NGLOB. The Condition Editor is used to enter application logic and define conditions for transitions among story units (→ sequencing of story units in Story-based DEGs, see also section 1).
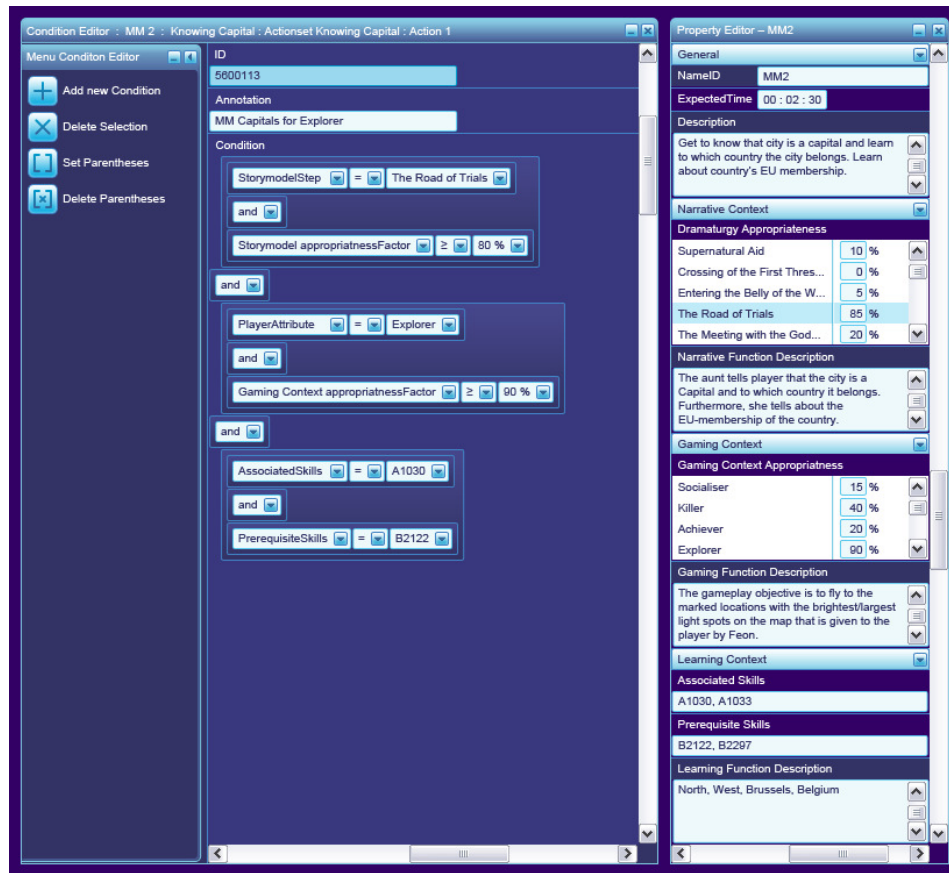

Fig. 6. Condition Editor (left) and Property Editor (right).

The result of the authoring process are ICML-encoded stories. These ICML files are loaded into the run-time environment of the 80Days framework in form of an executable story graph in the Story Engine. Then, the story starts and unfolds according to the user/player/learners´ interactions, behavior, rules and application logic provided by the author, and context information. The context information of NGLOBs is held within the content layer (repository, see lower part in figure 7) and the modeling part (see upper part in figure 7).

Concerning the control of Story-based DEGs and sequencing NGLOBs, the modeling part of the framework provides a player and learner model [4] plus a configuration component: Here, the author can provide priorities for narration, gaming and learning. Hence, possible conflicts in the sense of 'it is possible to continue the story with NGLOB A, NGLOB B or NGLOB C' (which all fulfill the conditions for transitions to following story units) practically do not occur.
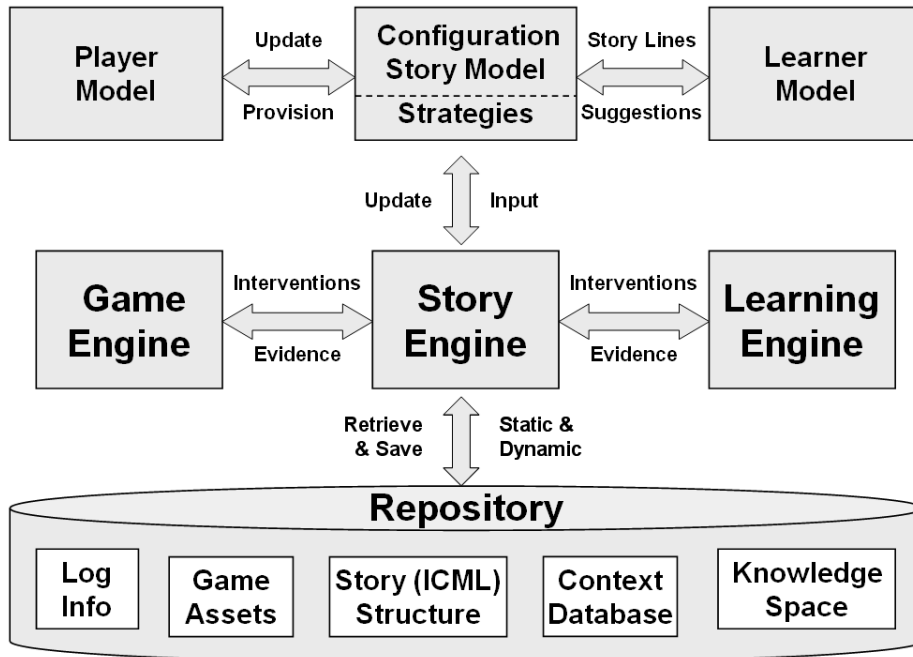

Fig. 7. High-Level Architecture of the 80Days Framework.

6 Conclusion

Based on preliminary, long-term research in the field of story-based edutainment applications and DEGs, this paper introduces the conceptualization of Narrative, Game-based Learning Objects (NGLOBs) as the basis for Story-based DEGs. The main result represents a first version of a formalized model for NGLOBs composed by narrative, gaming and learning context. The model has been technically implemented in the form of an XML schema being used as extension for the ICML format and has been rudimentarily integrated into the StoryTec authoring environment and the 80Days run-time system.

Apart from typical testing evaluation studies, further research and development activities will be investigated a) to continue and enhance the model of NGLOBs and b) to integrate methods and concepts of player and learner models.

Acknowledgements

References

1. Albert, D. & Lukas, J. (Eds.): *Knowledge spaces: theories, empirical research, and applications*. Mahwah, NJ: Lawrence Erlbaum Associates (1999).

2. Bartle, R. *Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDs*. In The Journal of Virtual Environments, 1(1), (1996).

3. Campbell, J. *The Hero with a Thousand Faces*. 1st edition, Bollingen Foundation, 1949. 2nd edition, Princeton University Press. 3rd edtion, New World Library (2008).

4. Conlan, O., O´Keeffe, I., Hampson, C. and Heller, J. *Using Knowledge Space Theory to support Learner Modeling and Personalization*. In: T. Reeves & S. Yamashita (Eds.), Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2006, pp. 1912-1919. Chesapeake, VA: AACE (2006).

5. Göbel, S. and Becker, F. *INSCAPE – Interactive Storytelling for Creative People*. In Proceedings of EVA 2005 Berlin, pp. 136-141 (2005).

6. Göbel, S., Malkewitz, R. and Becker, F.: *Story Pacing in Interactive Storytelling*. In Pan, Z., Aylett, R., Diener, H., Jin, X., Göbel, S., Li, L., eds. : Technologies for E-Learning and Digital Entertainment 3942, pp. 419-428. Springer, Berlin / Heidelberg (2006).

7. Göbel, S., Mehm, F. and Radke, S.: *80Days: Adaptive Digital Storytelling for Digital Educational Games*. In: Proceedings of the 2nd International Workshop on Story-Telling and Educational Games (STEG'09). Edited by Cao, Y, Hannemann, A., Manjón, B.F., Göbel, S., Hockemeyer, C. and Stefanakis, E. Published on CEUR-WS:03-Sep-2009, http://CEUR-WS.org/Vol-498/ (2009).

8. Göbel, S., Salvatore, L., Konrad, R. *StoryTec: A Digital Storytelling Platform for the Authoring and Experiencing of Interactive and Non-linear Stories*. In Nesi, P., Ng, K. and Delgado, J.: 4th International Conference on Automated Solutions for Cross Media Content and Multi-Channel Distribution, pp. 103-110. IEEE computer society (2008).

9. Göbel, S., Salvatore, L., Konrad, R., Mehm, F.: *StoryTec: A Digital Storytelling Platform for the Authoring and Experiencing of Interactive and Non-linear Stories*. In Spierling, U., Cavazza, M., Peinado, F., Aylett, R., Swartjes, I., Kudenko, D., Young, R., Tychsen, A., Pizzi, D., El-Nasr, M., eds. : Interactive Storytelling 5334, pp. 325-328. Springer, Berlin / Heidelberg (2008).

10. Göbel, S., Salvatore, L., Konrad, R., Sauer, S., Osswald, K.: *U-CREATE: Authoring tool for the creation of interactive storytelling based edutainment applications*. In Cappellini, V., Hemsley, J., eds. : EVA 2007 Florence Proceedings. Pitagora Editrice Bologna, Bologna (2007).

11. Hoermann, S., Hildebrandt, T., Rensing, C. and Steinmetz, R.: *Resource Center - A Digital Learning Object Repository with an Integrated Authoring Tool Set*. In: Kommers, P., Richards, G., eds. : Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2005, pp. 3453-3460. AACE, Chesapeake, VA (2005).

12. Hoffmann, A., Göbel, S., Schneider, O. and Iurgel, I. *Storytelling-based Edutainment Applications*. In: Tan, Ledo (ed.): E-Learning and Virtual Science Centers. Hershey, Information Science Publishing (2005).

13. Kickmeier-Rust, M., Göbel, S., Albert, D.: *80Days: Melding Adaptive Educational Technology and Adaptive and Interactive Storytelling in Digital Educational Games*. In Klamma, R., Sharda, N., Fernández-Manjón, B., Kosch, H., Spaniol, M., eds. : Proceedings of the First International Workshop on Story-Telling and Educational Games 386. CEUR Workshop Proceedings (2008).

14. Kriegel, M., Aylett, R. *Emergent Narrative as a Novel Framework for Massively Collaborative Authoring*. In Gratch, J., Prendinger, H., Ishizuka, M., Marsella, S., Pelachaud, C., Kopp, S., Kipp, M., André, E., Rehm, M., Aylett, R., eds. : Intelligent Virtual Agents 5208, pp. 73-80. Springer, Berlin / Heidelberg (2008).

15. Louchart, S. & Aylett, R. *Solving the narrative paradox in VEs – lessons from RPGs*. In: Intelligent Virtual Agents, 4th International Workshop IVA 2003. Eds. T. Rist, R. Aylett, D. Ballin. LNAI 2792, pp. 244-248. Springer (2003).

16. Louchart, S. & Aylett, R.S. *Narrative Theory and Emergent Interactive Narrative*. International Journal of Continuing Engineering Education and Life-long Learning. Special issue on narrative in education. Vol 14 no 6, pp. 506-518 (2004).

17. Vogler, C. *The Writer´s Journey. Mythic Structure for Storytellers and Screenwriters*. Michael Wiese Productions, California (1998).