Visualizing Knowledge in the Era of Instructional Software and Gamification: Challenges in Design, Method and Practical Use

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Abstract: The present study examines behavioral and metacognitive effects of visualizing acquired knowledge in instructional software. This was done by letting 117 Swedish primary school students use two varieties of an educational game – one with and one without a tool where tokens with knowledge related content were received as proofs of achievement. Although no significant positive impact of the tool was found, the study reveals interesting findings regarding the challenges of visualizing knowledge in learning applications.

Introduction

The role of metacognition in learning has been a hot topic during the last decades (Greeno, Collins and Resnick, 1996; Hattie, Masters & Birch, 2016). Research findings on the subject also reveal that didactic interventions, such as regular visualizations and reviews of student achievements versus goals and sub-goals, can have a significant impact on learning outcomes (ibid.). In addition, other studies indicate a need for decreasing the gap between the student's and the teacher's appreciation of the student's own knowledge and understanding (Zohar, 1999). When it comes to digital learning environments, these issues have often been emphasized when promoting or discussing e-portfolios or LMS's (Paris & Paris, 2001). However, to the author's knowledge, the topic has never been investigated in instructional software. Typically, in learning applications, learners perform a series of exercises without saving any substantial traces of them. After finishing the tasks, the possibility of reviewing or evaluating the obtained know-how is very limited. Subsequently, the aim of the present study has been to design and evaluate a function that preserves and presents achievements in an educational game. Hence, the following hypotheses were formulated: i) A visual representation of the student's obtained knowledge will catch the student's attention, and it will be interacted with during play, ii) Such representations will serve as motivational tokens and will affect self-regulatory aspects, e.g. endurance at voluntary play.

Method

The software used in the study was *Guardians of History (GoH)*, an educational game for students in the 4th to 6th grade that has been developed and utilized as a research instrument by Lund and Linköping University in Sweden (Kirkegaard, 2016). In the game, students are given missions for which they perform time-travels to historical persons and events, explore these environments, and solve tasks. The metacognitive support designed for the study had the shape of a diary, called "*the Magic Book*". The diary was placed as a clickable feature in the upper left corner of the screen and contained information about completed, ongoing and future missions. After solving a task or a sub-task, the player received tokens in the shape of souvenirs, corresponding to graphical objects from the original time-travels. These souvenirs represented the semantics of the student's correct answers from the tasks and was accompanied by textual information. To attract the student's attention, the book blinked anytime a new souvenir was added.

Five classes were recruited from two Swedish primary schools and two versions of the Magic Book - one with the functionality and graphics presented above (Type B), and one where the content was limited to a help-page (Type A) - were equally distributed within each class. In total, 117 11-12-year-olds (61 girls and 56 boys) participated. Each class spent three lessons with the study. The sessions were conducted in ordinary class-rooms, and all participants received the same instructions and support. Between the second and third session, half an hour (or longer, depending on the students' interest) was designated to play-time at home. The third session contained tests and inquiries (belonging to this and another concurrent study on cognition and learning), and discussions on user experience and general game improvement.

Results

As dependent variable for testing the first hypothesis: *"The visualization of the user's knowledge will be attended to and interacted with"*, the time spent (in seconds) on clicking and hovering on elements of the Magic Book was used. A Mann-Whitney's U-test here revealed a large and significant difference between Type A (*Mdn* = 10, *Range* = 0-105) and Type B (*Mdn* = 158, *Range* 0-607); $W = 286$, $p < 0.001$. For testing the second hypothesis: "*The visualizations will affect self-regulatory aspects of game behavior"*, the student's amount of

playtime at home (in minutes) was selected as a dependent variable. In this case, a Mann-Whitney's U-test (W =1397, p = 1) revealed no significant differences between conditions. Additional quantitative findings from data logs indicated further, that the main part of the time spent in the Magic Book was in the very beginning of the game. The players also dedicated most of their time to briefly scan through the content in the diary and very little time was spent on hovering the souvenirs for displaying textual information.

The students' subjective responses were analysed inductively, resulting in four relevant aspects of game design related to learning and metacognition: *Challenge, Simplification or scaffolding, Exploration* and *Learning and meaning.* In sum, the students requested an engaging application with a thrilling content, accompanied by meaningful rewards that later could be used as leverage for new tasks – a common structure in computer games. However, medium and high performing students made comments on the possibility of storing books and historical inventions from time-travels, and also requested opportunities to repeat tasks and topics. Interestingly, these students mainly came from the Type A condition – without the souvenirs in the Magic Book.

Discussion

The lack of positive metacognitive impact of the Magic Book might, of course, depend on its specific content, but it could also be due to constraints and affordances of digital medias in general. For example, a screen-based application has a sequential nature with limited physical space and dimensionality. Consequently, one activity (e.g. interacting with a parallel tool) easily overshadows another (e.g. the actual game-play), affecting cognitive resources as well as user experiences. An alternative design could therefore be to utilize the flow and narrative of a game for repeating and visualizing learning progress. In GoH, this might be done by adding game-elements where new assignments reflect earlier achievements, by forcing the players to attend to old performances through special tasks, or by reformulating dialogues and displayed information. The figure below shows the present conceptual structure of the game together with an alternative design where the diary is updated fewer times and with a more mandatory and meaningful use of it. Finally, it is also highly likely that such a design would benefit from a more iterative design-and test process with qualitative data collection, as well as more direct instructions before actual play.

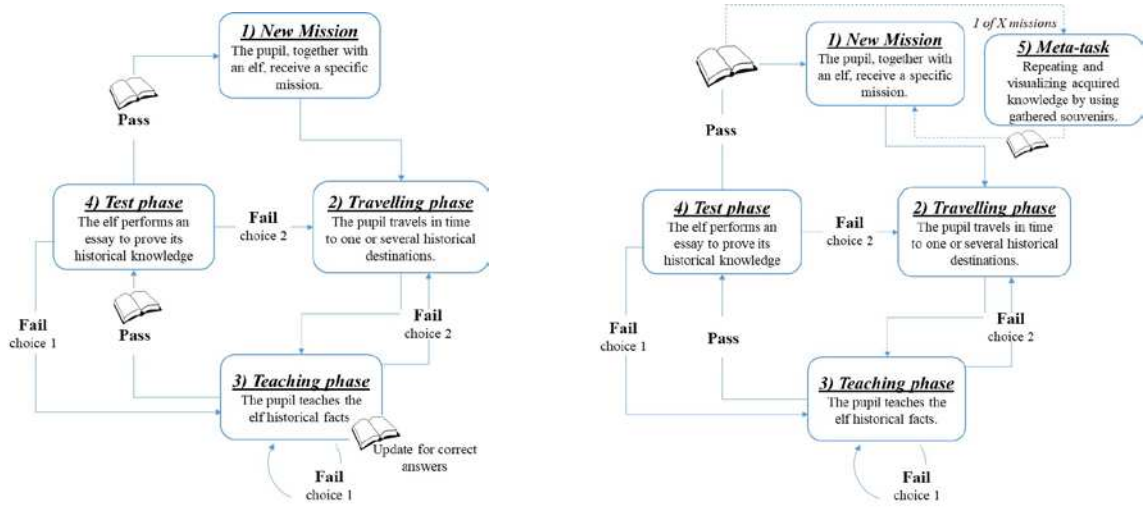

Figure 1. The structure of Guardians of History, with the tested design of the Magic Book (left) and an alternative design (right). The book icon shows when the Magic Book was/could be updated with new content.

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