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Visualisation of student learning model in serious games

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ABSTRACT

Application of serious games in distance learning can raise quality of education and student satisfaction on a higher level. However, when student learns through game, his focus is moved from learning domain to different context of the game. This actually enables to achieve fun and learn at the same time. But this approach also makes harder for educators to track and analyse students learning progress during game session, which is crucial in order to provide immediate feedback and to help students reach established learning goals. Such a specific learning environment requires concrete real-time analytical tool that will adequately match the dynamic game environment. This paper proposes a new tool for visualisation of student learning model during gameplay session. Tool can be used by educators and by students to track the game progress. Using this tool educators are provided with real-time tracking of students learning and it enables them to react and influence the overall learning process. Evaluation of the proposed approach was done through an empirical study, conducted on educators group monitoring an educational game session, using the combination of traditional analytic tool and the newly proposed visualisation approach. Initial quantitative results and recorded opinions of the participants speak in favour of the proposed approach and justify further investment in development of this specific learning analytics method.

1. Introduction

Application of serious games in distance learning can raise quality of education and student satisfaction on the higher level. However, when student learns through game, his focus is moved from learning domain to different context of the game. This actually enables fun and learning in the same time. But this approach also makes harder for educators to track and analyse students learning progress during game session, which is crucial in order to provide immediate feedback and to help students to reach established learning goals. Such a specific learning environment requires a specific real-time analytical tool that will adequately match the dynamic game environment.

Existing distance learning environments, such as LMS (Learning Management System) usually apply log analysis, produced by student's activities, and apply some data mining methods on them in order to discover useful patterns (Colomo-Palacios, Casado-Lumbreras, Soto-Acosta, & Misra, 2014; Jovanović, Vukićević, Milovanović, & Minović, 2012). Such approach enables post-festum learning analytics. Unfortunately, similar approach applied in the domain of educational games would not be so effective, since things are more complicated, mostly due to the complex nature of the games. While student plays the game, his focus is on the player goals and solving game puzzles, while the educator is concerned with learning goals and learning progress. Hiding learning context behind playing is what makes learning through games more fun and consequently more motivating for students.

Our research problem is how to enable teacher to track and analyse students learning progress in real-time, during the educational game session. Approach that will be presented is part of our efforts to expand learning platform produced and maintained by our team, based on the educational games development framework (Minović, Milovanović, Lazović, & Starčević, 2008). The platform provides educators with the ability to define a 2D adventure game and gives students the ability to play such a game via browser or mobile phone (Minović, Milovanović, Štavljanin, & Starčević, 2010). Students' knowledge is represented by student overlapping model (Brusilovskiy, 1994), while learning path is modelled using primitives defined in our framework. In order to provide educator with real-time feedback on students' progress, we will propose visualisation of students' knowledge by new kind of graphical representation. Using that tool, the educator will be able to track how well the student grasps the provided knowledge. Additionally,

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based on that information he can assess student or influence his game plan in order to support him.

In the next section we provide a brief literature review on the area of learning analytics and educational games. After that, we define problem statement, followed by models relevant to knowledge modelling in Section 4. Section 5 describes our educational game development environment from the educator's perspective. Next section presents a new approach to visualisation of students' knowledge. Section 7 is devoted to an experimental study conducted to evaluate the proposed approach. Final section is dedicated to discussion and conclusion.

2. State of the art

It is a common fact that new generation of students finds traditional methods of teaching less suitable. Our students are no longer the people that our educational system was designed to teach (Minovic, Štavljanin, & Milovanovic, 2012; Sancho, Gómez-Martín, & Fernández-Manjón, 2008) and also the formality of traditional learning materials is increasingly transforming to more popular informal approach (García-Peñalvo, Conde, Johnson, & Alier, 2013; García-Peñalvo, Johnson, Alves, Minović, & Conde-González, 2014). That is why many researchers are attempting to find a way of including student's daily activities, such as video games, into educational process (Hatton, Birchfield, & Megowan-Romanowicz, 2008; Kurniawan, 2008). It is claimed that electronic games can inspire players to explore new ideas and concepts (Hoffmann, 2009).

Games are distinguishing as a great channel for knowledge transfer. They have the ability of holding participants attention by creating an impression of fun in learning. In regard to technology advances, computer games are taking a dominant role in learning through games. For that reason we proposed and developed a software system that provided the ability of developing educational games with no need of programming skills and that provided educators a good way to integrate knowledge (Minović et al., 2008). Its upside is reusability of knowledge as well as multimedia game content (graphic, music...).

Important issue that opens in regard to educational games is finding a way of performing analytics and retrieving quality information from the learning process intertwined in a vivid, real time game environment. Learning analytics is a fast-growing area of Technology-Enhanced Learning (TEL) research. It is the use of intelligent data, learner-produced data, and analysis models to discover information and social connections, and to predict and advise on learning (Siemens & Baker, 2012). It has strong roots in a variety of fields, particularly business intelligence, web analytics, educational data mining and recommender systems (Ferguson, 2012). As Duval asserts, learning analytics focuses on collecting traces that learners leave behind and upon that, using those traces to improve learning (Duval & Verbert, 2012). There are different approaches and strategies to achieve this. Some consider how to process traces algorithmically and discover patterns (Romero & Ventura, 2007) while others attempt to visualise and exploit such information (Duval, 2011). Both strategies can be joined in order to facilitate decision-making.

Our paper considers using learning analytics in educational games for the purpose of visualizing learning information. Since this is a relatively new field, not much was done in research on this topic. Some authors propose an approach that relies on gathered data graphically presented to teacher with an extra layer that enables automatic inferring of conclusions from game-specific data (Serrano-Laguna, Torrente, Moreno-Ger, & Fernández-Manjón, 2012). Other authors try to define a general model for application of learning analytics to games, taking into account common game characteristics and therefore a basic but fundamental set of interaction traces for analysis (Serrano, Marchiori, del Blanco, Torrente, & Fernandez-Manjon, 2012). Some research directions led to application of these techniques to assessment of students' performance in educational games (Ketamo, 2012). There are also experiences that applied educational data mining techniques, such as cluster analysis of logs in order to identify learning patterns from students' play (Kerr, Chung, & Iseli, 2011).

When it comes to information visualisation, one approach focused on how visual cues could be used to support learning by, for example, increasing student motivation to work with non-mandatory content (Ahn & Brusilovsky, 2009). Building up a holistic picture of student progress and taking sentiment into account in order to enable 'computer-based systems to interact with students in emotionally supportive ways' is now seen as a real possibility (Blikstein, 2011). New tools such as the GRAPPLE Visualisation Infrastructure Service (GVIS) do not deal with just one LMS, but can extract data from different parts of a learner's Personal Learning Environment (PLE) and employ these data to support meta-cognitive skills such as self-reflection (Mazzola & Mazza, 2011). Some researchers dealt with the use of visualisation in different perspective. Instead on providing information analysis they used it as a part of the learning process or as a supportive resource for coursework (Lauer, 2006; Dicheva, Dichev, & Wang, 2005; Robling et al., 2006).

Visual analytics is a research area that draws roots from the fields of information visualisation. While purely automatic or purely visual analysis methods were developed in the last decades, the complex nature of many problems makes it indispensable to include humans at an early stage in the data analysis process. Visual analytics methods allow decision makers to combine their flexibility, creativity, and background knowledge with the enormous storage and processing capacities of today's computers to gain insight into complex problems (Keim, Mansmann, Schneidewind, & Thomas, 2010). The goal of visual analytics research is to turn the information overload into an opportunity. The specific advantage of visual analytics is that decision makers may focus their full cognitive and perceptual capabilities on the analytical process, while allowing them to apply advanced computational capabilities to augment the discovery process (Keim, Mansmann, Schneidewind, Thomas, & Ziegler, 2008).

We believe that providing educators and students with real-time visualisation tools is essential for success of educational games. With the help of analytic tools, students and instructors can better understand the learning process and take action to improve learning outcomes.

3. Problem statement

Distance learning makes education accessible to a broad audience. There is no constraint of physical presence and teacher can work with a larger group of students. Although working at a distance is convenient, such a form of knowledge exchange is usually the cause of disconnection between educator and student. Communication in person helps educators grasp the specific progress of students learning. In this case, teachers lack the visual cues that can signal when students are not sufficiently challenged, when they are bored, confused, overwhelmed or simply absent (Ferguson, 2012).

One of the most important things in running a successful educational game session is feedback on student's progress. Educator needs a tool to help him monitor learning progress for entire students group as well as for each student individually. This way, he can assess students, and based on that, moderate game session and perform corrections to the game world in real-time. This