Guest Editorial: Special Section on Game-Based Learning

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1 Introduction

Edutainment and serious games introduced a new important marketing direction for practical technologies such as multimedia communication, computer-human-interaction, and ubiquitous computing. This exciting outcome also pointed out the educational potential using computer games. Several commercially succeeded games, although not intentionally designed, have interesting learning, socializing, and interacting strategies embedded in them. These fundamental and intrinsic learning aspects of successful games must be investigated. How to explore pedagogical principles for serious games, to design and implement systems for Game-Based Learning (GBL), and to assess student learning achievement are essential.

GBL, according to Wikipedia (http://en.wikipedia.org/wiki/Game_based_learning), is a branch of Serious Games. GBL uses game technologies, while presenting learning materials in a game story, to attract and encourage students to apply subject matters to the real world. With the development of pervasive and communication technologies, GBL further allows students to play and learn in a social community. The experience is successful in that students are engaged in a deeper manner to a subject. As a consequence, in most cases, the motivation of the student is higher and the learning performance can be improved.

There is no limitation of subject or course for GBL. However, a few studies suggest that GBL is closely related to problem solving, which leads to problem-based learning and inquiry-based learning. Thus, "learning-by-doing" seems to fit the theme of GBL.

There are some definitions of game taxonomies or game genres. Game taxonomies can be divided into action games, adventure games, fighting games, Role Playing Games (RPGs), simulations, sports games, and strategy games. However, some games fall into more than one category. For instance, a basketball game can be regarded as a strategy game and a sports game.

There still exists a fundamental issue of whether GBL technology really helps students in learning. Traditional pedagogical models for instructional design and assessment need to be enhanced to consider using video games for education. Thus, a model bridging between the educational considerations and the usage of technologies has become essential. In addition, the strategy to evaluate the successfulness of GBL is necessary.

This special section focuses on the Information and Communication Technologies (ICT) for GBL. In the next secton, we briefly discuss a few current research trends.

2 Information and Communication Technologies for GBL

GBL uses technologies from different areas. Although educational technologies usually focus on cognitive psychology, learning design, and assessment, here, we only study technologies that are related to ICT. The following sections point out some important issues.

2.1 Virtual Reality and Human-Computer Interaction

The history of technologies for video games starts from the development of 3D computer graphics with limited control devices such as a joy stick or PlayStation 3's game controller. In order to support realistic scenes, virtual reality and augmented reality systems can be built in a cave, with more sophisticated interactive devices such as wired gloves, the Wii Remote, and Kinect. With the advances of image and video processing technology, realistic scenes with video tracking techniques allow advanced simulation games to be developed. Although these advanced technologies are not only used for GBL in general, networked virtual reality systems, such as Second Life by Linden Lab, are commonly used in GBL studies.

2.2 Mobile/Ubiquitous/Pervasive GBL

One advantage of using mobile devices for learning is to incorporate location-aware scenarios [1] for situated learning. Location information can be computed using GPS (higher location accuracy) or WiFi/ZigBee (lower location accuracy) by triangulation. In addition, mobile devices can be connected to RFID readers to detect RFID tags attached to specific objects (the highest location accuracy). One scenario is to use a mobile GBL system called Explore [1] to teach middle school students history in an archaeological park. Cellular phones are equipped with GPS devices to compute location information. Students also carry backpacks with speakers, which play location-aware sounds. Upon receiving guidance, students are able to check the

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location on a paper map and to compare preconstructed 3D virtual objects with the real scene.

2.3 Collaborative GBL

Multiplayer online games can be used as a platform to encourage collaborative learning. As a practical experiment, a 3D scripted game environment [4] was developed to support students' interactions while they are divided into groups to solve problems. The results suggest that collaboration on practical problems is easy. However, a higher level of collaboration under such a game environment is difficult, since how to effectively encourage collaboration under such a 3D environment is critical. It is important to identify the type of collaboration that can successfully support learning.

2.4 Social Networking and GBL

Games can be built on Online Social Networks (OSNs). Although [2] does not address GBL in general, it points out an interesting conclusion that games developed based on a social graph (such as Facebook) inherit similar social properties. The distribution of player interaction follows the Power Law decade of cumulative distribution, similar to the scale-free networks. However, the limitation of platform capacity may result in a clear cut-off in distribution. Online video games create social networks. With the development of GBL technologies, social networks may realize another perspective of successfulness in education.

2.5 Personalization and Adaptive GBL

The behavior of players in adaptive games can be described as schemas [3], which could be used actively as cognitive models within a game engine. Predesigned schema models can be regarded as knowledge representations to control and achieve specific effects while interacting with players. For instance, if schemas are properly integrated with instructional design strategies, adaptive games can assist students in learning.

3 Summary of Papers in This Special Issue

This special issue received a total of 39 submissions. Although many articles contained solid research contributions, we accepted only six papers to ensure a very high quality special issue. These six papers cover methodology, GBL technologies in practical usages, and adaptive techniques. The first paper, entitled "Games Methodologies and Immersive Environments for Virtual Fieldwork," discusses a virtual environment to support exploratory learning through excavation scenarios. The approach is confirmed by positive user evaluation in archaeological education. In addition, the paper proposes a framework to integrate games methods with learning management systems and virtual worlds. The second paper, entitled "Critical Factors for Technology Integration in Game-Based Pervasive Learning Spaces," provides a detailed account of the design, usage, and experiences of seven mobile learning games for assisting participants in gaining in-depth knowledge. The paper also proposes a model to integrate context, pedagogy, and game-design requirements. The model allows the designers and developers to select suitable requirements. In summary, the first two papers focus on design methods, frameworks, and models.

The third paper, entitled "An Evaluative Study on VISOLE—Virtual Interactive Student-Oriented Learning Environment," studies a creative constructivist approach to teaching generic problem-solving skills within a multidisciplinary context. Contributions include the discovery of impediments to students' learning processes as they use VISOLE and Farmtasia, and how these impediments will influence future refinements of VISOLE. The qualitative findings in this study, in particular, help advance the field by providing shemes that other researchers could include as predictors of learning and engagement outcomes for GBL implementations. As another practical usage of GBL technology, the fourth paper, entitled "Teaching Boolean Logic through Game Rule Tuning," proposes using game rule tuning activities of the Pac-Man game for teaching Boolean Logic. The authors design an interface of a scratch programming tool to allow students to change the game rules easily and play the game after changes. The realization from Boolean Logic expressions to a real world case is usually difficult for students to imagine. Accordingly, the idea of teaching Boolean Logic through appropriate game rule tuning may solve the difficulty. The above two papers demonstrate the practical usage of GBL technologies.

The fifth paper, entitled "Annie: Automated Generation of Adaptive Learner Guidance for Fun Serious Games," builds on a guidance model to integrate pedagogy with core gameplay components. Knowledge-representation and planning in Artificial Intelligence are used. The outcome includes a generative model that is able to automatically generate adaptive learner guidance in GBL. Another contribution of the paper is in the introduction of remediation in the execution cycle using measures such as MGPR to statistically determine how remediation should be executed. The last paper, entitled "Guided Game-Based Learning Using Fuzzy Cognitive Maps" presents a game-based learning framework based on Fuzzy Cognitive Maps (FCMs). It utilizes FCMs to allow a teacher's knowledge to be modeled. The authors also use FCMs to formulate a student's knowledge and show how it can be built up to match the teacher's knowledge. To demonstrate the feasibility, a driving training system is implemented. The last two papers present adaptive techniques in GBL.

4 Suggested Research Directions

GBL does not only mean using video games in education. It is necessary for game designers, game engineers, and educational professionals to work together to build high quality GBL systems and content. Although this special section does not cover all important technologies, a few additional issues can be considered as future research directions:

- **Practical guidelines for linking content to games.** Although there are models for GBL development, it is still a difficult but critical issue to properly link content and flow of experience into video games.
- **Taxonomy of games for education.** Different academic subjects might need different types of video

games. Although there are taxonomies for games, an analysis strategy of game taxonomy for education is helpful.

- **Quantitative metrics for the evaluation of GBL.** GBL increases the motivation of studying. However, a quantitative metric of the improvement could be useful. In addition, the assessment of student performance needs to distinguish whether a student successfully plays a game or in fact learns the material.
- **Social games for collaborative learning.** With the recent development of social computing, social games will further play an important role in GBL. The development of collaborative learning can take game technologies into consideration.
- **Adaptive technologies in GBL.** The study of individual differences in social networks and gameplay is important. Adaptive technologies to support different types of students while they are playing social games are interesting issues to be investigated.
- **Advanced ICT.** The use of advanced ICT is important. With the recent development in Human-Computer Interaction technologies, super-realistic and high resolution graphics, and 3D video technologies, there are technical challenges ahead, from both engineering and sociological perspectives.

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