Tutoring and Assessment Through Games and Emotions

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Abstract: Research in psychology, neuroscience, pedagogy, and cognitive science has shown that emotions (or affect) play a key role in the learning process, decision making, understanding of a problem domain and motivation to learn. As a result, researchers have been working on the creation of affective tutoring systems. Meanwhile, game-based learning is becoming more and more popular and it is considered as an emerging technology that will have a large impact on education in the next 2-3 years. Therefore, there is no doubt that researchers believe that the combination of educational games and affective tutoring systems may improve students' performance. The aim of this paper is to describe the current state of this research direction and to identify gaps and possible opportunities for the future work. Research shows that the main emphasis is on the adapted teaching/learning process that takes into account both student's knowledge and emotions but the aspect of the assessment, which also is an integral part of this process, has been neglected in tutoring systems that include emotions and game-based interactions.

1 INTRODUCTION

Since 1970-ties the research is being carried out for the development of intelligent tutoring systems (ITS) that try to imitate human teachers and their teaching methods. However, recent study in psychology, neuroscience, pedagogy, and cognitive science has shown that emotions play a key role in the learning process, decision making, motivation, and understanding (Ahn and Picard, 2005). As a result, over the last decade researchers inspired by the close relationship between emotions and learning have been working on the integration of an affective component into human-computer interaction. This has led to creation of a new generation of ITSs – affective tutoring systems (ATSs) that are capable not only to act as traditional ITSs and to implement all components of the tutoring process but also to perform adaptation to an emotional state of the student and to show system's own emotions using pedagogical agents.

In parallel to this research direction, another field related to educational technologies is becoming increasingly popular – game-based learning (GBL) and digital educational games. GBL is considered as an emerging technology that will have a large impact on education in the next 2-3 years (Kerfoot and Kissane, 2014). Therefore, there is no doubt that researchers believe that the combination of educational games and ATSs may improve students' performance and attitude toward the learning process (Novak and Johnson, 2012).

Despite the research carried out so far and the already designed ATSs (including those few tutoring systems that use game-like activities), the problem of how to adapt tutoring not only to a student's knowledge state but also to his/her emotional state has received much less attention. Since this question is mainly related to changes in ITS's pedagogical actions then it is closely connected to the implementation of the pedagogical module. This component imitates the human teacher, determines appropriate tutoring strategies, and manages the entire teaching/learning process including tutoring of the theory and practice, as well as assessment of student's knowledge. In fact, the assessment process is the one that mostly involves negative emotions (e.g. anxiety or fear) that can inhibit learning and negatively influence the reasoning and performance of the student (Petrovica, 2014). Therefore, the aim of this paper is to describe the current state of this research direction and to identify gaps and possible opportunities for the future work, as well as the architecture of a game-based ATS focused on the assessment of student's knowledge is proposed in this paper.

The structure of the paper is as follows. Section 2 describes the concept of ATS and explains the role

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of emotions in the learning process. Section 3 is devoted to the GBL and presents ATSs which use game-like interactions in the tutoring process. Section 4 introduces the current state in the game-based assessment and discusses identified types of the assessment used in games. Section 5 describes the developed architecture of a game-based ATS incorporating games as a tool for the assessment of student's knowledge. Conclusions and planned future work are presented in Section 6.

2 AFFECTIVE TUTORING SYSTEMS

ITSs are a generation of computer systems which aim to support and improve teaching and learning process in certain knowledge domain, considering individuality of a student like in traditional one-to-one instructional process, which, according to B. Bloom (1984), is an ideal condition for learning. Thus, an effective ITS should simulate what good human teachers do when carrying out individualized tutoring process. Consequently, the development of ITSs is related to a number of serious challenges because appropriate implementation can be done only having expertise in such fields as psychology, computer science, and pedagogy (Stankov et al., 2008). The traditional architecture of ITSs consists of components that store three basic kinds of knowledge (Figure 1): domain knowledge (Problem domain module), pedagogical knowledge (Pedagogical module), and knowledge about the student (Student diagnosis module). Recently, a fourth component was added to the architecture – the Interface module that is responsible for the interaction with students (Han et al., 2005).

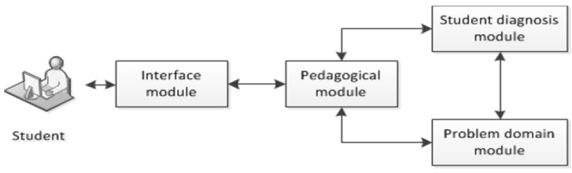

Figure 1: The traditional architecture of ITSs.

Over the past few decades, research in neuroscience and psychology has shown that emotions are fundamental to learning because they have an effect on perception, attention, decision making, motivation to learn, understanding of a problem domain, as well as acquisition, creation, and retrieval of knowledge (Taylor, 2001; Wilkinson, 2013). It has been shown that positive emotions, such as engaged concentration, joy, and excitement, can lead to increased learning, facilitate long-term memory, retrieval, and working memory processes and thereby can potentially improve motivation, creativity, and problem-solving skills. Alternatively, negative emotions, such as frustration, boredom, and anger, may lead to decreased motivation and desire to avoid the fulfilment of tasks (Novak and Johnson, 2012).

As a result, the field of ATSs has started to evolve by integrating into the traditional ITS the ability to recognize student's emotions and to respond to them in an appropriate way in order to enhance student's performance (Ochs and Frasson, 2004; Li et al., 2014). In such a way, the system becomes more flexible, adaptive, and natural in terms of similarity to the traditional learning environment, but in order to develop such a tutoring system, special attention should be paid to the pedagogical module and tutoring strategies that take into account not only the student's current knowledge state but also adapt tutoring to his/her emotional state (Petrovica, 2013). In fact, there are even more factors related to student himself/herself and learning process that should be considered when implementing the adaptation of the tutoring process, e.g. personal needs and interests of a student, his/her learning style and progress on the tutorial task, tutor's domain knowledge, and pedagogical objectives (Murray et al., 2004).

3 GAME-BASED LEARNING AND EMOTIONS

GBL is the subject of increasing attention mostly because it is thought that games increase motivation, interest, and learning (Sabourin and Lester, 2014). Educational games are games that are designed to help people to learn about certain subjects, expand concepts, understand an historical event or culture, or assist them in acquiring skills as they play. Realizing the psychological need and benefits of gaming in the learning process, this educational tool has become increasingly popular. Computer games have now been accepted as a tool within academia and even industry training. They are used for teaching different problem domains, e.g. science, education, mathematics, foreign languages, reading, physics, health, etc. (Shute and Ventura 2013; Kerfoot and Kissane, 2014).

Games are interactive and adaptive form of play that includes goals, rules, outcomes, and feedback

(main elements of any teaching/learning process), as well as develops problem solving skills, presents challenge and competition and encourages social interaction between multiple players (Kamenetz, 2014). They provide fundamental needs for learning by giving enjoyment, encouraging involvement, increasing motivation, doing, flow, learning, adrenaline, creativity, social interaction, and emotions (Prensky, 2001; Bonnycastle, 2009).

More than one learning style is also supported in GBL because information is provided in various formats, although the preference in most games is for information to be visually presented. By providing information in multiple formats (visual, textual, auditory, etc.), students cannot only choose a style that matches their own preference, but they can also practice their skills in others (Becker, 2005).

Games are voluntary, internally motivating, and involve active cognitive, physical, and/or affective engagement that allows for the freedom to experiment, fail, and recover from failures (Shute and Ventura 2013). It has been shown that attention, memory and motivation are main aspects affectively influenced through GBL and that principles from affective computing can assist in the development of these areas (Wilkinson, 2013). Since student engagement and motivation are critical aspects in improving learning gains within educational learning environments then the encouragement of positive affect and engagement while students are learning have become the main design goal of many learning environments. GBL offer significant potential for increasing student engagement and motivation (Sabourin and Lester, 2014).

As a result, researchers believe that the combination of educational games and ATSs may improve students' performance and attitude toward learning and instructional tasks (Novak and Johnson, 2012). The research in emotion recognition domain can also positively influence the field of educational games, since the success of digital educational games depends on the system ability to provide gaming characteristics such as feedback and challenge to student's cognitive and affective states (Yannakakis and Paiva, 2015).

However, currently only a few ATSs are developed as game-based environments. *Prime Climb* (Conati et al., 2013) created for learning number factorization skills, *CRYSTAL ISLAND* (Sabourin and Lester, 2014) developed as 3D narrative-centred learning environment for eighth-grade microbiology, *PlayPhysics* (Munoz et al., 2011) and *Newton's Playground* (Andres and Rodrigo, 2014) designed for tutoring basic physics concepts and principles, can be mentioned as examples of such kind of systems using embedded pedagogical activities as engaging and game-like interactions. Although emotional reactions are not widely modelled in educational games and small number of ATSs exploits GBL as main teaching approach, the application of games for the knowledge assessment is used even more rarely in tutoring systems (Li et al., 2014).

4 ASSESSMENT OF GAME-BASED LEARNING

Over the past several years, GBL and assessment have emerged as a promising area of innovation in education. Actually, the assessment of learning is considered to have the greatest influence on the next generation of educational games. It is well-suited to measure new learning standards, can provide authentic assessment activities and situations for meaningful tasks, and can enhance the teaching and learning process (Tucker, 2013). Therefore, many educators and researchers see digital games as potential learning and assessment environments for the 21st century (Asbell-Clarke et al., 2013). In fact, games are all about constant assessment. They do not teach directly but rather provide constant challenges and then give feedback on decisions (Fujimoto, 2011).

In recent years, the research on the identification of possible types of the game-based assessment (GBA) has been carried out (Ifenthaler et al., 2012; Asbell-Clarke et al., 2013; Shute and Ventura 2013). Currently, it is possible to identify two most commonly used assessment methods: external and internal (embedded or in-game) assessment (Hainey et at., 2012; Ifenthaler et al., 2012; Whitton, 2014).

External assessment is not a part of the game-based environment. It is realized through reports, interviews, knowledge maps or causal diagrams, and test scores based on multiple-choice questions or essays, therefore it is more time consuming and labour intensive (Hainey et at., 2012; Whitton, 2014). Since this assessment type is usually performed after tutoring process, it often focuses on the outcome and does not allow conclusions on the cause of a possible incorrect result. In addition, an educational assessment after playing the game cannot involve instant feedback while playing the game (Eseryel et al., 2011; Ifenthaler et al., 2012).

Internal assessment is a part of the game and can be carried out without interruption of the game

(Hainey et at., 2012; Whitton, 2014). This type is also called "stealth assessment" because it is integrated as a part of the game and aim to support learning, maintain flow, and remove (or reduce) test anxiety at the same time not losing the validity and reliability of the assessment. Stealth assessments are typically developed using the evidence-centred design (ECD) framework that aims to establish a logical alignment between the domain being assessed (competency model), assessment task design (task model), and interpretation (evidence model) (Shute and Ventura 2013; Asbell-Clarke et al., 2013). In contrast to previous assessment type, the internal assessment mostly focuses on the process. Also tracking of motivational, emotional, and meta-cognitive characteristics during game-play can help to better understand the specific behaviour and final outcomes (Ifenthaler et al., 2012).

Currently, GBA and games designed particularly for the assessment are only starting to evolve. The first educational game *SimCityEDU: Pollution Challenge!* intended for GBA was developed in 2014 by GlassLab (GlassLab, 2014). It incorporates an assessment engine that is used to assess both students' individual knowledge and understanding. As asserted by authors of the game, it aims to evoke and measure real learning in real ways using both summative and formative tests (Kamenetz, 2014). However, it should be noted that this educational game focuses only on the knowledge assessment and disregards player's emotions during the game-play. Therefore, the consideration of students' emotions in the assessment of the learning effect and combination of GBA and ATSs is encouraging area for research positively influencing the development of tutoring systems that are able to recognize emotions and respond to them accordingly.

5 GAME-BASED AFFECTIVE TUTORING SYSTEM

As it was mentioned at the beginning of paper, the pedagogical module of ITSs is responsible for the selection of tutoring strategies. Most strategies, regardless of their complexity, are based on a fundamental three-step process – teaching or presentation of the theoretical material, practice through exercises or applied scenarios, and knowledge assessment by providing feedback to the student after testing (Petrovica, 2014).

For limited or narrow problem domains (or particular topics from wider problem domains like mathematics or physics), the creation of an ATS as a game-based environment that gives only explanations about misunderstood concepts and is intended mostly for developing practical skills, is appropriate. But in case of more extensive problem domains covering many topics, it will be almost impossible to carry out teaching/learning process without tutoring theory and training practical skills. Therefore, GBL and GBA could be integrated in ATSs tutoring wider problem domains as one of the components to improve their adaptability, ability to influence students' emotions, to engage students in the teaching/learning process, and to assess their knowledge.

Keeping in the mind this idea, the architecture of ATS has been developed to include traditional architecture of the ITS, integrate the modelling of the student's emotional state and implement game-based knowledge assessment as a part of the pedagogical module (Figure 2). This figure shows the general architecture of the planned system, the main functions of each system's module, as well as presents the Pedagogical module in detail showing how it will be divided in three main parts. Each of the parts corresponds to one of the three previously mentioned fundamental steps of tutoring strategies. To create a more student-centred system (thus giving the student more freedom) both the tutoring of the theory and the practice is divided into two modes – managed by the student and managed by the tutoring system depending on the personality of the student. Also the GBA is planned as a two-mode implementation when the student can choose between single-player and multi-player versions because for some students the result will be important only for them, while for others competition with other players will be essential for their personality.

In addition, the determination of the student's emotional state is intended during all three steps in order to make changes in the tutoring process. Changes can be applied in various forms – different presentation way of the theoretical material can be chosen to support the student's learning style, difficulty level of a practical task can be changed in order to challenge student's skills and abilities, or the game can be paused to offer the additional theoretical material or to provide assistance in case of difficulties with the task solving.

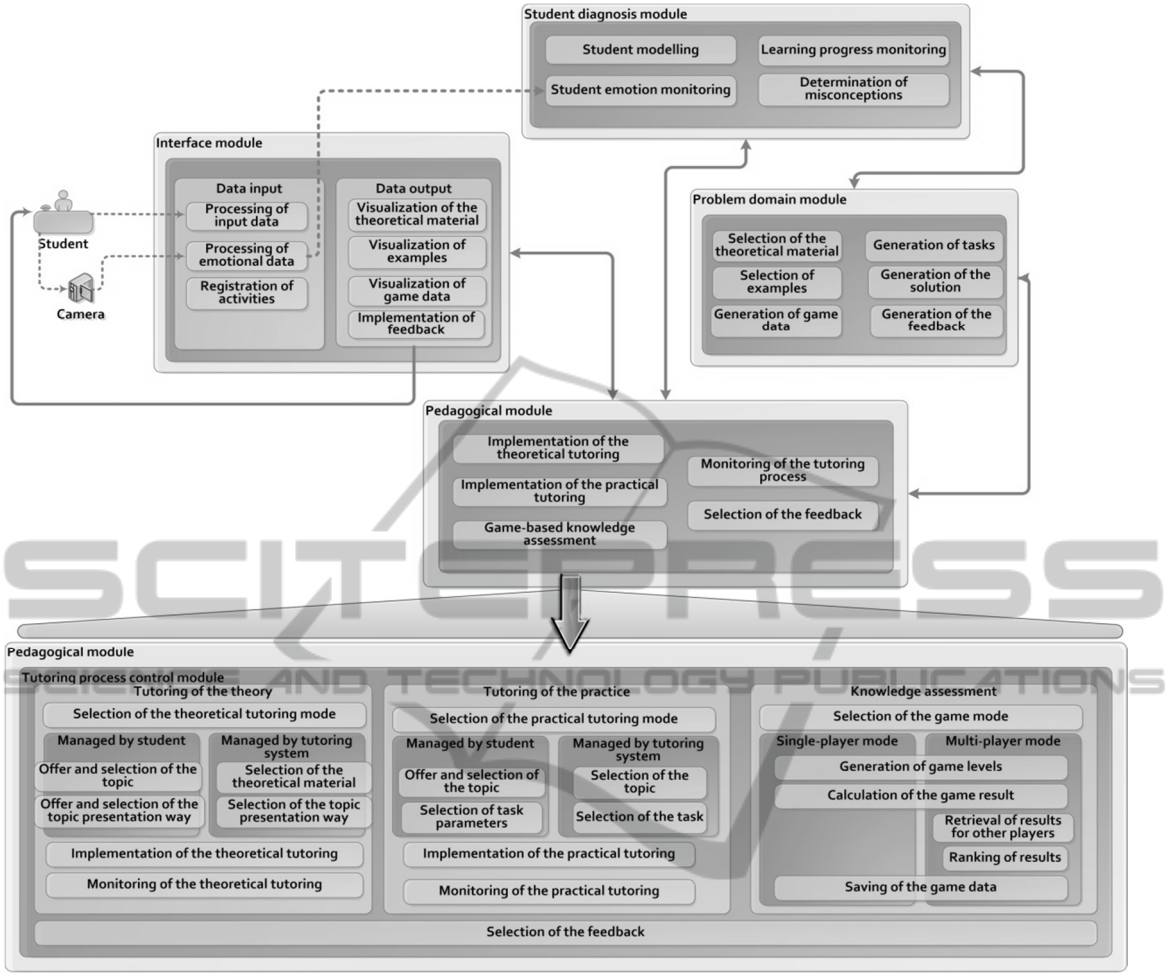

Figure 2: The architecture of ATS integrating game-based knowledge assessment.

6 CONCLUSIONS

The concepts of ITS and ATS are discussed in this paper as well as the role of emotions in the learning process is explained. Furthermore, GBL that is becoming more and more popular is presented describing also the influence of games on learning process and student's emotions. The application of GBL in ATSs and examples of such kind of systems are also given. However, it should be noted that ATSs using game-like activities are not so common and are mostly used to teach narrow problem domains or particular topics from wider fields. Moreover, games are used to provide knowledge to students and to develop practical skills but not to assess them in these systems. One of the possible reasons for this can be the fact that the process of design and implementation of assessment features into GBL environments adds a very time-consuming step to the design process, as well as this research direction and development of such game-based systems focused on the assessment are only at an early stage. Therefore, research related to the combination of game-based knowledge assessment with ATSs is promising area for the development of such tutoring systems.

The architecture of ATS incorporating game as knowledge assessment tool in the pedagogical module is designed in this paper. This work has been carried out to supplement an existing theoretical research on the GBA and to improve capabilities of already developed ATSs in terms of the assessment of student's knowledge using game-based interactions. The proposed architecture of ATS is planned to be implemented as tutoring system for the study course related to fundamentals of artificial intelligence (AI), particularly for tutoring and assessing knowledge of AI search algorithms.

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