MATE: Next Generation Intelligent Tutoring Entities for Virtual Environments

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Abstract - *MATE is an intelligent tutorial system that is supposed to combine innovative pedagogical techniques from the field of coaching and to provide intelligent technological solutions for support the coaching processes in an autonomous and smart way. Conceptually, the system is composed of two distinct components, an afferential component that is 'harvesting' information coming from the virtual environment (e.g., behaviors or communication patterns) and an efferential component that is capable of making psycho-pedagogically tailored interventions (e.g., hinting or moderating the communication processes, posing new problems and questions or giving feedback, etc.). Both components are orbiting around a central executive which controls the tutorial process, draws conclusions on the basis of the input, and decides upon interventions on an individual basis as well as on the group level. MATE is work in progress; this paper gives an outline of conceptual approach and draws a sketch of the envisioned system architecture.*

Keywords: Intelligent tutorial systems, educational agents, CbKST, coaching, virtual worlds, Second Life

1 Introduction

Twenty-first century education clearly is a big buzzword in today's media. The new millennium is accompanied by substantial technological evolutions; we became a highly diverse, globalized, complex, real-time media- knowledge- information- and learning society. Since the 1990s, the progress of media and technology was breath-taking; during these one or two decades, we were facing the rise of a serious and broad use of computers at home (although the development started earlier, of course), the rise of the internet and how it revolutionized our society, becoming a "collective unconscious" (in the words of Carl Gustav Jung). We faced the spread of mobile phones and their evolution from telephones to omnipresent computer and communication devices; we see spread of mp3, twitch speed computer games and TV shows. We saw how our world got closer by changing the bridges over continents and oceans from 56k wires to hyper speed fiber glass networks. Some say, this rapid and pervasive technological revolution will have greater impact on society than the transition from an oral to a print culture.

But what does this mean for educational systems and the way our children learn and what they learn. Today's kindergarten kids will retire in 2070. Facing the pace of technological and societal changes and demands, we cannot predict what knowledge will be required in such a "far" future. But we are in charge to equip our children with the abilities and backgrounds to survive in that world. Our students are also facing many important emerging issues such as global warming, famine, poverty, health issues, a global population explosion and other environmental and social issues. These issues lead to a need for students to be able to communicate, function and create change personally, socially, economically and politically on local, national and global levels.

Soft skills such as innovative thinking, creative problem solving, meta cognitive abilities, communication and collaboration skills – all those so-called 21st century skills – need to be in the focus of novel smart tutorial systems. Presently, there are several techniques available that promote the 'acquisition' of such abilities. The problem is that most of those techniques are strongly centered on a face-to-face setting which, however, is costly and from a broader educational perspective ineffective – applications are oftentimes limited to leadership trainings for distinct groups of learners. Our aim is to elaborate on existing coaching techniques (such as Action Learning or Lego Serious Play) and to translate those real world approaches to the virtual worlds, for example Second Life. This is not a trivial attempt since virtual environments demand incorporating sound instructional design principles and, more importantly, they require educationally smart, autonomous tutorial mechanisms to control and guide the learning processes of groups of learners in the virtual worlds with their large degrees of freedom.

2 Innovative ePedagogy

Modern pedagogical strategies most often orbit around the idea of construction-oriented, active instructional design and learning theories, such as problem-based learning [1], learning by doing [2], experiential [3], or example-based learning [4] and also on communication-oriented approaches such as collaborative and peer learning [5]. In the conceptual context of an active and interactive, constructive view of learning and development, examples play a crucial role [6].

The second and probably broader concept is problem-based learning. The approach of problem-based learning is an integral part of many instructional models [7]. According to M. David Merrill [8] problem-based learning accounts for the fundamental premise “Knowledge is soon forgotten if it is not made a part of the learner’s life beyond instruction”.

Undoubtedly, also collaboration and communication among peers is a crucial aspect in the context of learning; there is a substantial body of evidence that peer interactions likely lead to superior learning performance and a more effective learning process [8]. One of the most compelling reasons for collaborative learning is that teachers/tutors cannot simply transmit (their own) knowledge to learners. Learning is an active, also neurological and physical, process and not a product. Students must build their own knowledge and competencies through an active, involved process in which they need to assimilate concepts into their own understandings and worlds. Social interactions in groups promotes an active involvement and mutual support (e.g., helping, assisting, supporting, encouraging, and praising one another's efforts to learn), it facilities discussions, opens new views, and it supports imitation [9]. In addition to that, there are also secondary effects reported, for example, learners tend to be more positive towards subject matter, schools, or towards each other [10].

An approach to facilitate learning, meta-learning, collaborative creative solutions, and self-reflective growing is action-oriented learning (AOL). The principal idea is that a team is working and reflecting on a realistic challenge in order to commonly develop novel and creative solutions and, equally important, to developed aforementioned abilities and meta-abilities in a collaborative process. AOL is based on the fundamental aspect of questioning; a thematically uninvolved outside moderator is guiding the process by asking appropriate questions and statements in the group work are only allowed in response to questions from the moderator or the group members.

A similar approach to top-level demands on future learning is creative serious play (CSP); the ideas of this approach are inherited from Lego Serious Play (http://www.seriousplay.com). In moderated team work, collaborative learning and problem solving, reflecting upon the group’s and the own ideas and work, and finding a common language is triggered by challenging abilities and meta-abilities through playing and modeling with building blocks. A key aspect of this approach is the successful and deep learning is fostered by touching, handling, and holding objects and by making tasks and problems ‘concrete’.

Both techniques are highly successful applied, predominantly in the organizational sectors and on a small scale. The reasons, in turn, are simple: the techniques are based on the work in small groups, in real-world settings, driven and hosted by professional trainers and coaches. An innovative idea that is presently work in progress in several research groups, particular in Europe, is to work on a conceptual combination of such coaching techniques. Such settings, however, cannot be transferred one-to-one to virtual worlds. Technological solutions are needed that are capable of purposefully translating and implementing AOL and CSP into the virtual reality. This, in turn, requires novel approaches to user and domain modeling, focusing not only on individual user models but models of users in groups and models of groups. In addition, domain models must be adjusted to meet the distinct needs of the “meta domain” of the 21st century skills.

3 Learning and Training n Virtual Worlds

Beginning in the late 1970s and early 1980s, tightly coupled with computer and information communication technology, immersive virtual environments and game-based worlds virtual worlds have increasingly become a major genre in the fields of entertainment but, specifically in the new millennium, they have become the places for social communication, working, teaching, and learning. This increasing use of virtual space in education suggests that the effects of virtual space on learning are an important area for continued [11]. There is a broad range of examples for virtual environments; famous World of Warcraft has far over 10 million users, for Second Life there are over 20 million registered accounts, or the popular Facebook application FarmVille has over 70 million active monthly users. The sight of this cake made mouths of serious applicants water, in particular in the educational sectors [12].

The potential advantages of virtual environments in education are numerous [13]. To give an example, virtual spaces serve as meeting points for distance education, basically due to the range of communication modes and options for collaboration (e.g., teachers and learners, represented by avatars, may interact via chat, voice, and non–verbal communication such as avatar placement and gestures [14]). Another perceived advantage of using virtual space in education is the high degree of customizability offered by some virtual spaces like Second Life [14]. The possibilities for adjusting the environment, e.g., building objects, of virtual spaces enables an educator to customize a learning space to fit a specific learning activity or a certain pedagogical approach [14]. In addition, since the laws of physics and other physical world occurrences can be disregarded in a virtual environment, virtual learning space can be used to visualize macroscopic and microscopic complex systems, manipulate time in a sequence of events, simulate scenarios, allow complex interactions, and create objects and content [13]. Certainly, the application of virtual environments, in particular the application of rich, immersive, 3D-ish ones, is not always viewed positively. A specific concern was that this rather novel educational medium must be applied cautiously and in consideration of potential risks and downsides (social isolation, un-reflected peer learning, misconceptions, addiction, etc.). Still, overall, the trend is clearly heading towards a pedagogically informed use of technology that may support and reinforce a wide range of traditional and innovative pedagogical. But, this increasing use of virtual space in education suggests that the effects of virtual space on learning are an important area for continued research. Although the current state of knowledge on how virtual space affects learning is very broad, there is substantial fragmentation of the various research streams. As suggested by Olle Sköld [13], especially in the field of an innovative “online pedagogy”, aiming to illuminate both practical and theoretical dimensions of learning and teaching in a virtual space settings, future research is required. Examples are, how learning tasks must be designed in order to account for features in specific virtual spaces, or which methods should be developed to handle ambiguity and uncertainty in virtual learning spaces.

4 MATE: The Next Generation of Intelligent Tutorial Entities

MATE stands for intelligent multi-adaptive tutorial entity; he idea is to advance and expand existing intelligent tutorial technologies, in particular from the context of CbKST [15] and digital educational games, towards the needs of 21st century skills and coaching in virtual environments. This – strongly service-oriented – technology must understand individual and group-related processes in the context of joint learning and problem solving and guide those processes in a smart and tailored way by meaningful tutorial, coaching-related interventions, for example, posing questions and problems to the group. In addition, this combination is to be enriched with features of individual and small-group coaching and some of the strength of today’s immersive and engaging media (such as computer games). This novel alloy – in hour firm conviction – has a maximum of strength for teaching and training in the context of the 21st century demands and a minimum of conceptual or application-oriented downsides (e.g., the substantial costs of personal coaching).

Technically speaking, the systems intelligence is to be based on reasoning mechanisms over the combination of structural domain models (the so-called competence structures), into which the learner can be mapped, and so-called problem spaces, formal, structural models of problem solving processes [16], into which a current problem solving state can be mapped. Prerequisite relations between atomic, well-defined competencies/skills (a) establish competence structures/spaces (b). The analysis of a given problem, in turn, established a formal problem space (c). Mapping both together results in a well-defined, formal model of the ‘behavioral’ status (of an individual) in the virtual world (composed of location in the problem space, problem solving path, available and lacking competencies/skills, learning paths, as well as the so-called fringes, the reasonable next steps in terms of learning and problem solving). This concept builds, in essence, the basis of the artificial educational intelligence. Non-trivial challenges for the project arise from the attempt to expand this approach to the distinct features of this project, e.g., the multi-learner approach or the natural language involvement.

The second major objective is enabling the system to respond educationally meaningful and effective to the conclusions drawn from the assessment procedures, still protecting immersion and flow. Feedback and interventions can be interpreted as one mechanism that overtakes action of a teacher, i.e., providing advice, explanations, and evaluations. In game-based learning situations, adaptations on the micro level may occur through embedded feedback (e.g., through a non-player character), by guiding or hinting, or by adjusting the complexity/difficulty of a learning situation. Such kind of adaptation may indicate gaps between current and desired performance level and may enhance motivation and task strategies, it is able to reduce learners’ cognitive load, and it can provide information that is useful for correcting inappropriate task strategies, errors, and misconceptions. A menu of psycho-pedagogically inspired adaptive intervention categories and types has been elaborated by [17], which are aligned with the non-invasive assessment procedures of a learner’s competence and motivation.

In a next step, we must extend this framework by factors referring to the multi-learner aspect; we need to have sound mechanisms for assessing informal learning in groups, collaboration, group dynamics and roles, social networks, identifying the strength (the knowledge) and weaknesses of individuals in the groups, or the shared understanding of an entire group. In addition, it is necessary to develop and advance the related adaptation and intervention mechanisms. We need robust methods to support suitable group formation, an adaptation to individuals within groups, and an adaptation the entire group (with all the distinct characteristics). A particular challenge arises from the need to adjust the repertoire of interventions to the special requirements of the distinct coaching techniques. This includes elements such as systematic and purposeful questioning, moderating interventions, mediating interventions, task generation in the “building block” context, tailored group formation and alignment, suitable action calls, etc. Finally, to complete the vision of an intelligent tutoring system for virtual coaching, it is of deemed importance to enrich the metrics used for the CbKST-based assessment with the interpretation of natural speech acts, the chatting and talking of learners/coachees. This goal requires a close collaboration with leading edge natural langue interaction techniques.

This paper presented the conceptual approach on the basis of the existing state-of-the-art. Realizing this vision is subject to future work.

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