

A Domain Model for Smart 21st Century Skills Training in Game-based Virtual Worlds

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Abstract— The demands of galloping societal changes and technical (r)evolutions on today's learners are immense. At present we need empower people to solve problems we do not even know yet. This requires a substantial change of education, away from teaching knowledge towards teaching meta-skills such as problem solving, non-linear thinking, creativity, or communication skills – the so-called 21st century skills. This is not trivial, since such meta-abilities cannot simply be tackled by conventional tutorial methods. IN this paper we briefly introduce an approach to systematize 21st century skills and to develop intelligent tutorial systems for this distinct domain.

Keywords—21st century skills, action learning, artificial intelligence, Competence-based Knowledge Sapce Theory

I. INTRODUCTION

Since the 1990s, the progress of media and technology was breath-taking; in a couple of years from the first home computers to omni-present smart phones. For educational systems and the way our children learn and what they learn that means a demand for a substantial conceptual change. Facing the pace of technological and societal changes and demands, we cannot predict what knowledge will be required in the future. Thus, schooling and educational systems must increasingly focus on those 21st century skills. Binkley and colleagues [1], defined those skills as ways of thinking, working, living, and as tools for working in connected, media-rich worlds. More concretely, what must be in the focus are skills such as innovative thinking, creative problem solving, meta-cognitive abilities, communication and collaboration skills.

Presently, there are several techniques available that promote the 'acquisition' of such abilities. Most of the techniques, however, are strongly centered on face-to-face settings, which is costly and from a broader educational perspective ineffective. Our aim is to elaborate on existing techniques and to translate those real world approaches to the virtual worlds, for example *Second Life* or *Serious Games*. 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.

II. 21ST CENTURY SKILLS AND SERIOUS GAMES

The nature of modern computer games provides a perfect context for the acquisition of those 21st century skills. Computer games offer a meaningful setup including a virtual environment and some sort of story. Within this virtual world the players need to improve their own abilities and they need to reflect upon their own progress, whereas reflection occurs in a mutual dependency with the immediate feedback coming from the game. Games, especially adventurous games, are oftentimes based on problem solving tasks and riddles. These activities, in turn, support not only the development of solving a particular problem, they rather promote the acquisition of a problem solving oriented mind set and, due to continuous occurrence of problems and tasks, general problem solving strategies. Many of today's games are multiplayer games, which promotes collaboration and communication skills, a team player attitude, and to some extends leadership skills (of course depending on personality characteristics).

In the focus of our research is to extend the natural strengths of serious computer games by highly effective techniques of meta-abilities, soft skills, and leadership skills coaching in small groups. One such technique is, for example, *action learning* (AL).

AL is a powerful action and problem solving oriented coaching approach that can be used to engage people and to develop leadership skills, communication and team oriented skills, collaborative mind sets, and meta-abilities such as self-reflection. In addition, it can be utilized to improve self-esteem and self-awareness. AL occurs in small teams, where each AL team will work on an important project or issue, leading to a deliverable outcome. The technique is based on experiential learning concepts and ideas of learning by doing. The concept was developed in the 1980s by Reginald Revans. The primary domain of AL was management and leadership training for high potential sin the private business sector. A popular model was developed by Michael J. Marquardt [2]; he claims that the greatest value of AL lies in its capacity of equipping individuals, teams, and organizations with the ability to accommodate new situations challenges, problems, and the need for change.”

In the focus of our present research is the fundamental question how, to what extent, and under which context conditions the approach of AL can be transferred to the

virtual world. This is a non-trivial question since the mechanisms of communication and cooperation in face-to-face settings versus virtual environments such as Second Life are substantially different. More importantly, it is necessary to equip the virtual systems with smart abilities to monitor, assesses, and understand group interaction as well as the problem solving processes in order to support (in the long term, to replace) human coaches. The most beneficial aspect in this attempt can be considered in the potential to expand the field of application from costly business coaching to a broader range of education, for example in schools.

The prerequisite for such attempt, however, is to develop a formal, structural, and semantically rich approach to 21st century skills. This formalization process must support technological solutions running in the background of a game or game-like virtual environment to understand the processes within the coaching sessions and to respond appropriately. Loosely speaking, the aim is to equip the system with a psycho-pedagogical intelligence. Role models for this work can be found in formal approaches to knowledge representation, for example that of *Semantic Networks* or that of *Competence-based Knowledge Space Theory* (CbKST) [3]. The latter has already been applied in the context of educationally intelligent serious games [4].

III. A FORMAL MODEL OF 21ST CENTURY SKILLS

The major challenge in this context arises from the unclear, probably vague, and highly informal nature of the 21st century skills. As outlined initially, the concepts is an overarching term for many kinds of meta abilities, soft skills, communication and collaboration skills, of attitudes, self-awareness, strengths in non-linear thinking, and innovative problem solving, as well as the ability to reflect about one's own thinking and being.

To search for a formal structure behind this complex domain, we developed a formal ontology model that models the skills by logical groups, involved cognitive, emotional, and social processes, as well as the developmental sequence of the skills. The present working model is illustrated in Figure 1. To give an example for the ontology model, the top level skill might be "identification of the status of a problem solving process (location in a problem space)"; the logical genre is "problem solving ability", one (of many) sub-competencies would be "identifying gaps in one's own knowledge", which in turn would refer to the cognitive domain. Prerequisite skills, again on a top level, would be "ability to examine and analyze evidence" or "identification major alternatives". The competence type for this example would be "declarative". Finally, we can assign a developmental stage or level, based on any model. In its simplest form the developmental model might be the levels high, medium, and low. An interesting aspect of the 21st century skills, as defined by [1], is an ethical component; They claim that the concepts is so intertwined with daily lives of people, that ethical aspects and attitudes play a crucial role. An example for such element would be "honest assessment of one's own biases". The benefits are:

(i) We gain a very precise definition and specification of a broad and oftentimes vague concept.

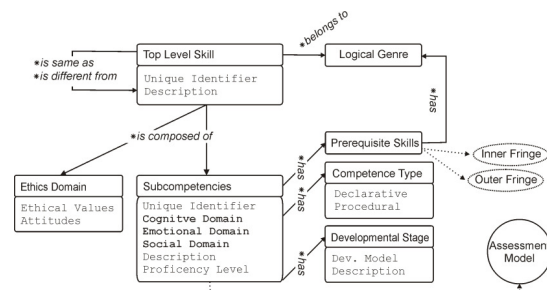


Figure 1. Example of a ONE-COLUMN figure caption.

(ii) We can derive a natural "curriculum" for teaching the concepts. The basis for these sequences comes from the, mutual dependencies and prerequisites between the sub-competencies and, subsequently, the top level skills. Such curriculum is important for a general attempt to teach 21st century skills and it is in particular important to equip artificial, educationally intelligent systems with the capacity to understand learning processes and react appropriately.

(iii) In addition to the benefits in (ii), an added value comes from the possibility to define inner and out fringes; most briefly those concepts refer to the notion of "what a learner can do/knows" and "what a learner is able to learn/acquire next" [3].

(iv) The formal nature of the model, that is, the CbKST-induced quasi order (establishing so-called competences spaces) and the ontology standard OWL provide a machine readable format. This, in turn, allows automatic reasoning over the ontology, which is important for realizing an educational intelligence.

(v) Finally, the ontology approach allows for linking other related ontology to the skill definition. For example, in the context of AL, language ontologies are important to realize smart coaching mechanisms, for example, by automatic question generation. In addition, also assessment models can easily be linked to the skills, for example, problem spaces or task models in virtual (game-based) environments.

The described model is a first draft to tackle the concept of 21st century in a formal way that is supposed to serve as the basis for intelligent tutorial systems, in particular intelligent coaching technologies, for example in the scope of AL. Such coaching technology remains an endeavor for future research and joint projects.

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