A General Knowledge Representation Model for the Acquisition of Skills and Concepts

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ABSTRACT

A cognitive model for skills and concepts representation as well as a proposal for its computational implementation is presented. The model is intended to help bridge some of the natural problems that arise in current massive education models, through the adaptation and personalisation of learning environments. The model is capable of representing rich semantic knowledge, including both, skills and concepts, integrating them through a coherent network of role based associations. The associations build an ontology that integrates on itself different domain taxonomies to represent the knowledge acquired by a student keeping relevant context information. The model is based on a constructivist approach.

Keywords: Concept Representation, Educational Model, Knowledge Acquisition, Knowledge Representation, Learning Model, Skills Representation

1. INTRODUCTION

Knowledge Representation is central to the study of Cognitive Informatics (CI) (Wang, 2002a; Wang, 2007), as such it is integrated into the Cognitive Informatics through Object Attribute Relation OAR model and Concept Algebra (Wang, 2006), Real Time Process Algebra (Wang, 2002b) and its Concept Learning Enginge (Tian, Wang, Gavrilo, & Ruhe, 2011). In this work, a model for knowledge and skills representation, called Memory Map (MM) is presented. The model which has a precedent in the Episodic Memory Model of Ramirez and Cooley (Ramirez, Carlos, & Cooley, 1997), and presents similarities with the OAR model, mainly, both store the concepts acquired during a learning process in a structured and flexible way: however, our model proposes a more flexible alternative as to some of the components of the CI framework, but it keeps the same approach of personalisation derived from a unique

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perception as established in the fundamental theories of CI2. Pedagogical related research in CI focuses on personalisation as can be seen in (Ramirez & Valdes, 2010; Ramirez & Valdes, 2011; Ramirez & Sanchez, 2012; Reynoso, Sanchez, Rodriguez, & Alvarez, 2012; Reynoso, Romero, & Romero, 2012).

The MM was originally created having in mind the development of Virtual Learning Environment Technology able to advance the current educational practices of instruction. The problem with current educational practices is rooted in historical reasons: since the beginning of the industrialisation age till now, many voices have risen against the process of massive education without significant success, e.g. (Kilpatrick, 1925; Lave & Wenge, 1990; Piaget & Inhelder, 1958; Vygotsky, 1986). Most of today’s modern educational systems have significant deficiencies that hinder the natural development of concepts and skills, giving as a result the development of poor quality knowledge, focused mainly on concept memorisation. Evidence of this can be observed in average students that memorise concepts, but remain unable to perform efficiently in real life situations, because of poor development of the skills necessary to apply such concepts on different contexts. What is even worse, a large amount of memorised concepts will be forgotten shortly unless deeply understood and frequently used. It is therefore important to enrich the educational process, taking advantage of modern technological tools, to facilitate the acquisition of concepts and the development of skills.

It must be understood that learning is an individual process; as such, an educational model oriented to standardisation, i.e., teaching the same content with the same methods, and at the same rate to every student, is inadequate. An individual learning process denotes a unique way of perceiving reality or the concrete world, people learn differently because they perceive the world in different ways. Unique perception of the world by each individual is one of the cornerstones of modern thinking, which is stated in fields such as biology (Maturana & Varela, 1980), education (Harel & Papert, 1991), psychology (DeVries, 2002), cognitive sciences (Winograd & Flores, 1987) and cognitive informatics (Wang, 2007) among many others. By individual we do not mean without cooperation, indeed social constructivist theory explains how these two work together (Vygotsky, 1986).

There is a latent necessity for technology that supports educational models that are not solely focused on the acquisition of concepts and memorisation skills, but also on the development and frequent usage of generic skills, including those for long life learning. An important example of this can be found in Reynoso, Romero, and Romero (2012) where Vygotsky’s zone of proximal development is formalised to be used with technological tools. To successfully implement such educational model, at least the following components are required:

- A computational representation of the student’s knowledge and skills, and an algorithm for the process of acquisition, which should be compatible with complex and evolving learning theories such as Constructivism (Piaget & Inhelder, 1958; Vygotsky, 1986; DeVries, 2002), Constructionism (Harel & Papert, 1991) and Transformational Learning (Mezirow, 1981) among others. Useful elements for both representation and acquisition algorithms are found in the CI theoretical framework of Wang, (2007), specifically in the OAR model and concept algebra (Tian, Wang, Gavrilova, & Ruhe, 2011).

- A virtual learning environment (Dillenbourg, Schneider, & Synteta, 2002) or, intelligent learning environment (Brusilovsky, 1994; Brusilovsky, 2001) with adaptive capabilities, such as presented in Torres, Doredo, Ramirez, Valdes, and Lugo (2009), where personalisation of learning resources is the main concern. The learning environment ought to be based upon pervasive computing (Hansmann, Merk, Nicklous, & Stober, 2003) where workbenches, which are currently being developed (Ramirez, Concha, & Valdes, 2010), and regular accessories: earrings,