Chapter 13
Tracing the Metacognitive Competencies of Online Learners

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ABSTRACT
The success of a learning environment can be measured in terms of improvement in learner performances as well as positive learner engagement in metacognitive traits. A large body of educational technology literature establishes a positive correlation between the application of learning technologies and learner performances. In addressing the other aspect of success, this chapter presents a study that lends support to positive learner engagement in the context of metacognitive traits induced through ontology-oriented learning technology. That is, learners are found to benefit from targeted metacognitive activities embedded in online learning environments. To reap this benefit, the educational technology system employed a theory-centric mixed-initiative approach that traces the metacognitive competencies of online learners. This chapter postulates that in addition to providing the metacognitive interface tracing the metacognitive competencies of online learners is critical for the success and sustainability of technology-enhanced learning environments.

INTRODUCTION
A significant portion of students graduating from academic institutions are unable to demonstrate effectively in our knowledge society mostly because they lack measurable study competencies (Bali & Alvarez 2004; Govt. of UK 1998). Measurement of study competencies at a distance, as in online learning, poses additional challenges as well as opportunities. Challenges such as authenticating student’s work, sustaining student’s motivation, accommodating student’s personal goals, validating the use of contemporary technologies,
and guiding students through learning activities have been of great interest to communities such as ICALT, UMUAI, STLHE, AIED, and so on, that are in pursuit of excellence in teaching and learning. Online learning also opens up opportunities such as socially engaging learners who are geographically apart, enabling learners to regulate their own study habits, and exploring instructional strategies at various levels of granularity.

Study competencies can be classified into two types – task-level domain-specific study competencies and meta-level domain-independent metacognitive competencies. Task-level competencies are, obviously, domain-specific. That is, learning activities corresponding to a particular subject area can be modelled in learner models. Models of learner behaviour, learner knowledge, learner goals, learner misconceptions, learner preferences, and other learner-specific aspects have been extensively studied over the last three decades. This chapter discusses research efforts that trace metacognitive competencies. In doing so, the chapter will promote model tracing as a complementary and sustaining mechanism to all existing data-capture mechanisms in learning technology.

In addition to dealing with task-level competencies, online learning also possesses the inherent capacity to explicitly observe or infer behaviours of metacognition, for instance, self-regulation. This chapter will only focus on metacognitive traits related to self-regulation. However, it can be stated that any educational theory can be computationally represented.

Self-Regulated Learning is a seminal metacognitive educational theory that explains learning underperformances in terms of adaptation strategies, learning transformations, and diversity in study habits among learners (Winne 2001; Winne & Hadwin 2002; Zimmerman 2000; Boekaerts, Maes & Karoly 2005; Gress & Winne 2007; Purdie N., Hattie J. 1999; Azvedo et al., 2006). Literature reports that high achieving learners exhibit discernible self-regulatory abilities such as goal setting, self-monitoring, seeking help, and self-efficacy, as well as subject-specific abilities such as speed reading, mathematical problem solving, and program design. This chapter presents a model-tracing technique that continuously measures and opportunistically promotes learners’ study competencies, over longer periods of academic and professional life. In doing so, it will argue that traced learner interactions in online (eBooks, learning management systems, and social networks) systems can be overlaid in a singular, ontology-based representation, at real time. This contention was tested in a small-scale study as a proof of concept and the results confirm the claim.

Research Background

Many systems in educational technology are built with minimal foundational connectivity with educational theories or social theories of human interaction processes. These systems employ a variety of knowledge representation schemes such as symbolic rules, fuzzy logic, Bayesian networks, neural networks, case-based reasoning, and even some hybrid approaches, without explicit theoretical connectivity between the knowledge that is represented and the interactions of the learners. Many researchers have advocated knowledge representation schemes for systems that hinted at the need for a theoretical basis to model learner interactions (Winne et al, 2006; Hearst, 1999). Of late, many educational technology systems have employed ontologies, semantic web, machine learning, dialogue based communication, and planning systems with explicitly represented theories of mixed-initiative interactions (Allen, 1999; Andersen et al., 1999; Boicu et al, 2003) that add a sense of naturalness (Hearst, 1999) to the represented knowledge.

Davis et al. (1993) takes a critical approach by defining knowledge representation to consist of five fundamental roles: surrogate, ontological commitment, fragmentary theory of intelligent reasoning, medium for efficient computation, and
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