http://www.DynaLearn.eu

Introduction

DynaLearn develops an Intelligent Learning Environment that allows learners to acquire **conceptual knowledge** by constructing and simulating qualitative models of how systems behave. DynaLearn uses **diagrammatic** representations for learners to express their ideas. The environment is equipped with **semantic technology** components capable of generating knowledge-based feedback, and **virtual characters** enhancing the interaction with learners (Fig.1).

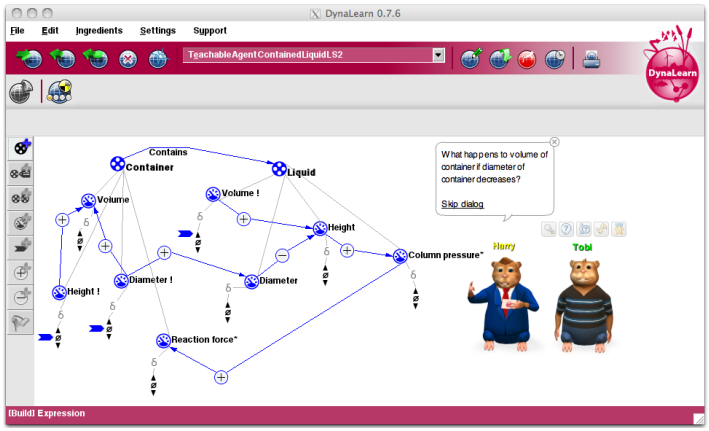

Fig. 1. The DynaLearn Learning Space 2 (in Teachable Agent mode) including a learner made diagrammatic expression (LHS), and two interacting virtual characters (RHS)

Background and motivation

The importance of **learners *constructing* their conceptual interpretation** of system behaviour while learning e.g. Physics, Biology or Environmental Science has been highlighted in many studies. From these studies it is apparent that there is a need for software that supports learners in ***actively* working and interacting with the theoretical concepts** involved. This can be achieved by having learners create models and run simulations from which they can make predictions and derive explanations. DynaLearn is motivated by this need, particularly for secondary and higher education (undergraduate level). The project integrates well-established, yet independent technological developments, and utilizes the added value that emerges from this integration (Fig. 2).

Using the DynaLearn workbench, **learners construct conceptual models by manipulating icons and using diagrammatic representations**. Simulating these models **stimulates reflective thought** on behalf of the learner, because it confronts learners with the **logical consequences of their ideas and insights** as expressed in the models. Moreover, within this workbench embodied **conversational agents** are situated and available for learners to further analyse and improve their models. This interaction is steered using **knowledge technology that generates feedback** based on a growing repository of models.

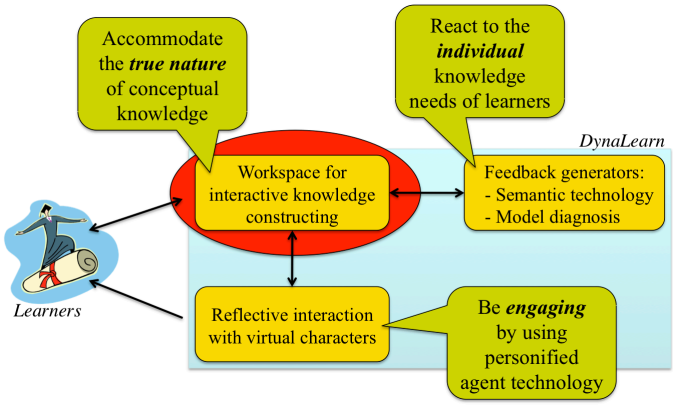

Fig. 2. The DynaLearn software consists of three main components. A workspace for creating knowledge, a semantic based feedback generator, and a set of virtual characters facilitating reflective interaction.

Learning by Modelling

There is ample research that points out the importance of learners constructing conceptual interpretations of systems' behaviour. **But what kind of tool is needed to accommodate the true nature of conceptual knowledge?** Addressing this question, DynaLearn has developed a set of six distinct representations, which act as scaffolds to support learners in developing their conceptual knowledge. The representations are referred to as **Learning Spaces**, and are **based on Qualitative Reasoning (QR)** technology. A qualitative model **provides formal means to externalize thought**. It captures the explanation that the creator of the models believes to be true of how and why a system behaves. The sequence of learning spaces facilitates a **progressive approach** where at 'the next level' learners are confronted with **additional and alternative expressive power** for representing and reasoning about the behaviour of systems.

Generating feedback using semantic technology

An innovative feature of DynaLearn is that conceptual models created by learners can be compared to models created by other learners or teachers, and based on that **automated feedback** can be provided. The feedback based on the **semantic technology** has three parts (Fig. 3). First, **OWL Export**: conceptual knowledge contained in models is extracted and expressed in OWL and available for processing using semantic technology. Second, **Grounding**: the terms from the conceptual models are linked to external vocabularies. These grounded models are stored in a semantic repository. Third, **Semantic feedback**: alignment and reasoning techniques are applied to discover similarities and dissimilarities among models. Based on this feedback is generated and communicated to the learner.

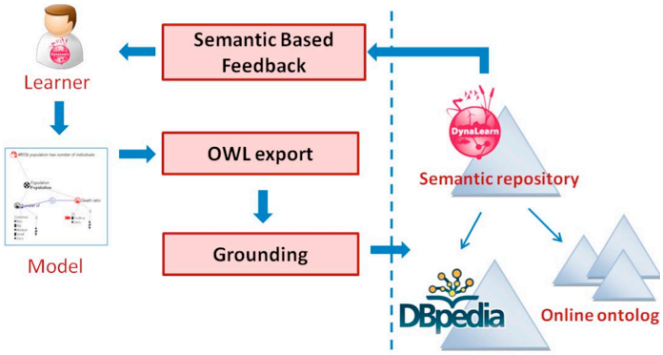

Fig. 3. Key tasks and interactions with the semantic based feedback component.

Communicative interaction using virtual characters

A distinctive feature of the DynaLearn approach concerns a **community of unique virtual characters** that accompanies learners in an **entertaining** and **motivating** way while **handling complex conceptual knowledge** (Fig. 4). The characters offer **basic help** as well as **sophisticated feedback** on the contents modelled by learners

Fig. 4. The DynaLearn virtual characters (from left to right): two students, the critic, the teacher, the quizmaster, and the mechanic).

Environmental science – Application and Evaluation

DynaLearn has created **didactic materials for teaching and learning environmental science**. Particularly, 173 models have been created covering 61 topics across the seven DynaLearn themes in environmental science. In total 22 evaluation activities were conducted. Overall the **studies showed the great potential of the DynaLearn approach** for supporting: the growth of causal system thinking; the acquisition of scientific reasoning skills; the ability to learn about complex ecosystems; the gradual construction of content knowledge; the development of the conceptual modelling approach and skills.