DynaLearn: Architecture and Approach for Investigating Conceptual System Knowledge Acquisition

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Abstract. DynaLearn is an Interactive Learning Environment that facilitates a constructive approach to developing a *conceptual* understanding of how systems work. The software can be put in different interactive modes facilitating alternative learning experiences, and as such provides a toolkit for educational research.

Keywords: Qualitative reasoning, Conceptual knowledge, ILE architecture.

1 Introduction

DynaLearn allows learners to acquire conceptual knowledge by constructing and simulating computer-based qualitative models of how systems behave [4]. DynaLearn is based on Garp3 [2] and uses diagrammatic representations for learners to express their ideas. The environment is equipped with components capable of generating knowledge-based feedback, and virtual characters implementing the communicative interaction with learners (see Fig 1). DynaLearn is applied and evaluated in the context of environmental science.

2 Conceptual Knowledge and Use-Levels

Six use-levels have been realized In DynaLearn (see [3] for full description). **Concept map** is a graphical representation (entity-relation graph) that consists of two primitives: nodes (concepts) and arcs (relationships between concepts). A simple version of such a workspace is available in the DynaLearn software. **Basic causal model** focuses on quantities, how they change and how this change causes other quantities to change. Simulation means calculating for each quantity one of the following options: decrease, steady, or increase. Augmented with a teachable agent this use-level closely

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relates to Betty's Brain [1]. **Basic causal model with state-graph** augments the previous level with the notion of quantity space. This has a significant impact on the simulation results (because quantities can now change values) and necessarily introduces concepts such as state-graph, behavior path, and value history. **Causal differentiation** refines the notions of causality. Processes are introduced requiring a differentiation between influences (I) and proportionalities (P). **Conditional knowledge**. Some facts only happen when certain conditions are satisfied (e.g. an evaporation process). This use-level introduces the possibility to specify conditions under which a specific set of details holds. The use-level **Generic and reusable knowledge** reflects Garp3 in its current status. The main difference with the other use-levels is the focus on 're-usable' knowledge.

When used in educational practice, use-levels can be used individually to focus on a particular phenomenon, or in a sequence to gradually refine someone's understanding of a phenomenon.

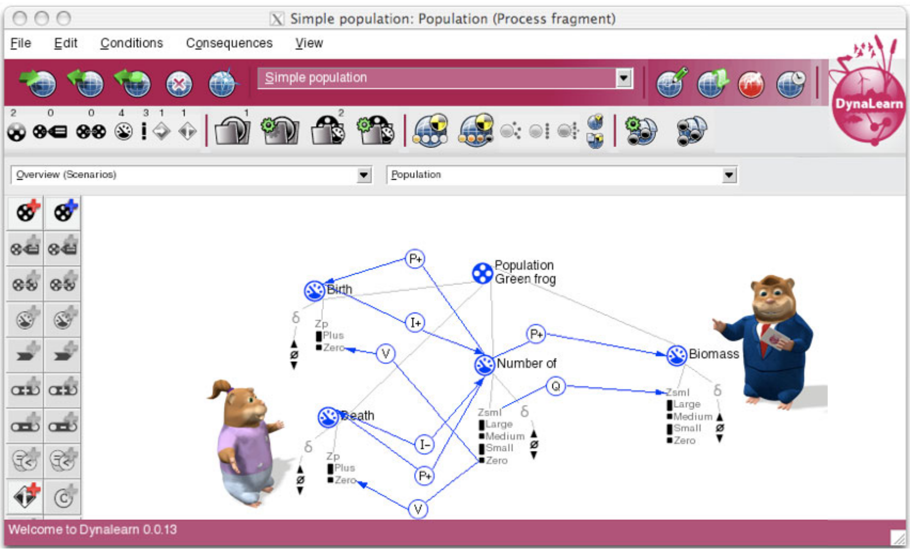

Fig. 1. Shown is a DynaLearn workspace with a diagrammatic expression and two interacting virtual characters, the Student / Learning companion (LHS) and the Quizmaster (RHS)

3 Knowledge-Based Feedback and Virtual Characters

One of the innovative features of DynaLearn is that a QR model created by a learner can be compared to QR models created by other learners and/or experts in order to automatically provide feedback and recommendations to that learner. This is made possible by converting the QR models into 'ontological' models. This conversion is performed in two main steps: (1) The QR model is automatically translated into the OWL language, identifying and extracting its relevant concepts and relationships, and defining them as ontology terms; and (2) a semiautomatic grounding process that establishes explicit links between these ontology terms and other terms coming from external ontological models and background ontologies. In fact, due to the grounding process, the models created by learners can be related to external knowledge sources enabling the reuse of well-defined vocabularies as well as the inference of new knowledge not asserted in the learner's QR model explicitly.

In DynaLearn the communicative interaction is mediated by a set of virtual characters. Virtual characters lead to an increased sense of ease and comfort, and are expected to have motivating effects on learners [5]. In DynaLearn the characters become active following requests by learners, who have the initiative and control. When activated, the characters react to the diagrammatic expressions created by learners. What content the characters will communicate depends on role they have, and is further fueled by the knowledge-based feedback mechanisms. Thus far in DynaLearn we have established characters following the metaphor of a virtual classroom: student, teacher and quizmaster.

4 Concluding Remarks

The DynaLearn project is an ongoing activity. Currently the following components have been realized: the conceptual modeling environment (including the use-levels), grounding and a simple version of the quality feedback, and the teachable agent and quizmaster. Ongoing research addresses the remaining knowledge-based feedback, and the development of an integrated coherent dialogue (currently each character has its own interaction schema with the learner). Considerable effort will be put in classroom evaluation of the different modes of interaction. Particularly, blending in with ongoing classroom learning activities such that undesired disturbances are minimized as much as possible, while the positive impact and learning enhancements caused by the DynaLearn innovation are maximized.

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