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Progressive Knowledge Representations for Learning Conceptual Knowledge of System Behaviour[2]

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Abstract

The work presented here is part of the DynaLearn project (http://www.DynaLearn.eu), which builds an Interactive Learning Environment to support a constructive approach to having learners develop a qualitative understanding of how systems behave.

There is ample research that points out the importance of learners constructing conceptual interpretations of system's behaviour (e.g. [3,5,7,10,11]). There is a need for software that 'goes beyond data handling' and supports learners in actively dealing with the theoretical concepts involved. This can be achieved by having learners create models and perform concept prediction and explanation [6,8,10]. However, such techniques are sparsely available or too complex to use, and therefore seldom part of prescribed learning activities [9].

This paper presents knowledge representations for articulating conceptual knowledge. Particularly, it discusses the idea of a set of representations, which act as sequence of progressive scaffolds to support learners in developing their conceptual knowledge. The representations are referred to as Learning Spaces (LSs) and based on Qualitative Reasoning (QR) technology (cf. [1,4]). A qualitative model provides formal means to externalize thought. It captures the explanation the creator of the models believes to be true of how and why a system behaves. The approach is domain independent.

In DynaLearn we utilize the full expressiveness and potential of the QR formalism based on Garp3 [2]. This allows us to divide the qualitative system dynamics phenomena over a range of LSs of increasing complexity, implementing a progression where at 'the next level' learners are confronted with additional and alternative expressive power for representing and reasoning about the behaviour of systems, and hence facilitating the construction of a better understanding of the phenomena involved. As such, six LSs have been designed and implemented, and will be discussed in the full paper: (1) Concept map, (2) Basic Causal Model, (3) Basic Causal Model with State-grap, (4) Causal Differentiation, (5) Conditional Knowledge, and (6) Generic and Reusable Knowledge.

Two aspects guided the design of the LSs: the logic of the representation and the ability for a representation to capture relevant system behaviour (for the latter, see the goals mentioned

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below in the sections describing each LS). LS1 is the smallest subset of ingredients that constitute a meaningful subset from the representation used by this engine. Effectively this subset of modelling ingredients allows the construction of concept maps, consisting of nodes connected by arcs. Defining a higher LS is done by augmenting the current space with the smallest subset of possible modelling ingredients while ensuring that the next level is self-contained. Self-contained implies that the representational primitives available within a LS form a logical subset of all the primitives available. Hence, they allow for automated reasoning on behalf of the underlying software. It also implies that from a Qualitative System Dynamics perspective, learners are able to create meaningful representations of the phenomena they perceive when observing the behaviour of a real-world system.

In the DynaLearn software, learners construct knowledge by manipulating icons, and their inter-relationships, using a diagrammatic representation. The diagrams represent models that can be simulated confronting learners with the logical consequences of the knowledge they represented.

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