DynaLearn - Engaging and informed tools for learning conceptual system knowledge

Bert Bredeweg (UvA), Asuncion Gomez-Perez (UPM), Elisabeth Andre (UAU) and Paulo Salles (FUB)

University of Amsterdam (UvA)
The Netherlands

This work is co-funded by the EC within FP7, Project no. 231526, http://www.DynaLearn.eu
Context and Relevance

• Having learners acquiring *conceptual* knowledge of system’s behaviour.
  – Important for society to successfully interact with its environment.
  – Being able to adequately explain and predict the behaviour of systems to utilise their functioning for human benefit.
  – A prerequisite for working with numerical models and equations.

• Hence, policymakers and other stakeholders strive to accomplish effective science education.
Problem statement

• Worrying decline in science curricula
  – Less students sign up
  – More students drop out

• Main reasons
  – Lack of engagement and motivation in science teaching
  – Lack of tools to interactively construct conceptual knowledge

e.g. Osborne et al. 2003
DynaLearn - Main objective

• To develop an interactive learning environment that allows learners to construct their conceptual system knowledge, either individually or in a collaborative setting.

• The workbench will have three strategic characteristics:
  – Accommodate the true nature of conceptual knowledge
  – Be engaging by using personified agent technology
  – React to the individual knowledge needs of learners

Integrate proven technology
Learning through conceptual knowledge modelling

• Modelling is fundamental to human cognition and scientific inquiry (cf. Schwarz & White, 2005)
• Traditional simulation technology
  “mimics the behaviour of a system”
• Qualitative Reasoning
  “captures human interpretation of reality”
  – Appropriate vocabulary (e.g. cause-effect reasoning)
  – No numerical ‘overhead’
  – Handles to automate interaction
• Challenge and innovation
  – Easy to use *multi use-level* workbench
  – Automated model feedback
    ▪ explaining discrepancies with expectations
Use-levels - Learning spaces

1. Concept map
2. Causal model - single state - dec/std/inc
3. Causal model - state graph - dec/std/inc - q-values
4. Causal differentiation - Rates & propagation
5. Conditional knowledge
6. Knowledge Re-use - Scenario & MF’s
4. Causal differentiation (Build environment)
Quiz - Question generation

- Build
- Simulate
  - QR model & Simulation
  - Question templates
  - Criteria: Selection & ordering
- Generate questions
- Learner
  - Question request
  - Determine focus
  - Bayesian Network
  - Process answer
  - Dialogue history
  - Express question
- Question
  - Select question
  - Question list
  - Quags (Goddijn, et al., QR03)
Engaging virtual characters

- Challenge and innovation
  - Handling conceptual knowledge
  - Handling complexity
    - e.g. large amounts of knowledge, rich vocabulary
  - Different agents for different ‘kinds of knowledge’
  - Meaningful dialogues on (multiple) model contents

Initiate always with the learner!
Semantic technology

• Challenge and innovation
  – (Interactive) model grounding
  – Similarity measure (indexing & ranking)
  – Semantic repository of conceptual knowledge

In the context of Qualitative System Dynamics
Character roles (preliminary)

- Basic help (what is, how to, ..)
- Advanced help (model diagnosis)
- Teachable agent
- Model comparison (dialogue)
- Critic
- Quiz
Competencies involved

- Understanding and using multiple representations.
- Identifying central and peripheral information, presented in different contexts.
- Integrating and using knowledge from different areas (e.g., natural sciences and humanities).
- Formulating and articulating adequate argumentation.
- Critically analyzing/comparing solutions for problems.
- Making logical inferences (e.g. inductive, deductive, analogical).
- Selecting explicative models, formulating hypotheses and predicting results.

List not complete...
Science education

• Interdisciplinary approach: Environmental science
  – Relevance for mankind apparent (motivating?)
  – Essential for solving contemporary problems
  – Supports the European agenda on sustainability

• Challenge and innovation
  – Rethink the administration of the subject matter
    ▪ Utilise the emerging DynaLearn software features
  – Establish semantic repository of explanatory models
  – Blend in with ongoing classroom learning activities
Typical evaluation questions

• Does the DynaLearn diagrammatic approach allow learners to address more complex problems?
• Does the meta-vocabulary from which a conceptual interpretation is built, provide an analytic instrument that enables learners to construct more fine grained and thorough analyses of how systems work?
• Do the embodied conversational agents establish the ‘involvement momentum’ required for learners to actually benefit from the added value provided by the software for handling conceptual knowledge?
• Do the instruments to individualise learning (ontology mapping, diagnostic procedures, and semantic repository) adequately steer learners in acquiring the target subject matter?
• Does the personal autonomy cause learners to be more motivated?
• Do learners actually learn better when using the full set of DynaLearn results? And are students more motivated to take on science curricula?
Conclusions & Expectations of the DynaLearn workbench

• Allows learners to articulate, analyse and communicate ideas, and thereby
  – Construct conceptual knowledge about scientific theories
• Engages learners in science education
• Reduces the perceived complexity
• Provides individualised feedback

Ultimate research question:
Under which conditions will learners be more motivated and achieve more?

http://www.DynaLearn.eu