JTEL 2010

Acquiring conceptual knowledge on how systems behave using Qualitative Reasoning technology

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Overview

- Introduction
  - Problem statement & context
  - Main objective
- Constructing conceptual knowledge
  - Example
  - Learning-by-conceptual-modelling
  - Learning spaces
- Educational components
  - Semantic technology
  - Virtual characters
  - Example: quiz
  - Science curricula
- Evaluation & conclusion

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
  - Teaching involves surface knowledge in terms of formulas and uninterpreted numeric data
  - Lack of interactive tools to construct conceptual knowledge

e.g. Osborne et al. 2003

Conceptual science education

Having learners acquiring *conceptual* knowledge of system's behaviour:

- Deep knowledge in terms of the *concepts* that are involved
- Learn basic principles that can be *carried over* to other problem instances
- Learn 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
- *Communicate* insights to the general public

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.
- Strategic characteristics:
  - Accommodate the true nature of conceptual knowledge
  - Be engaging by using personified agent technology
  - React to the individual knowledge needs of learners
  - Applied to the interdisciplinary curriculum of environmental science

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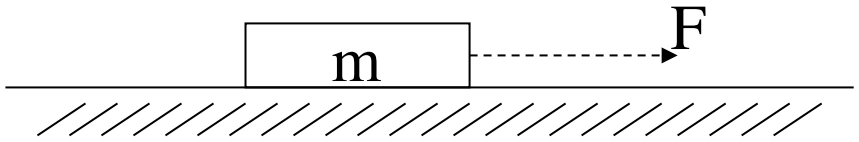
Example



$$F = m * a$$

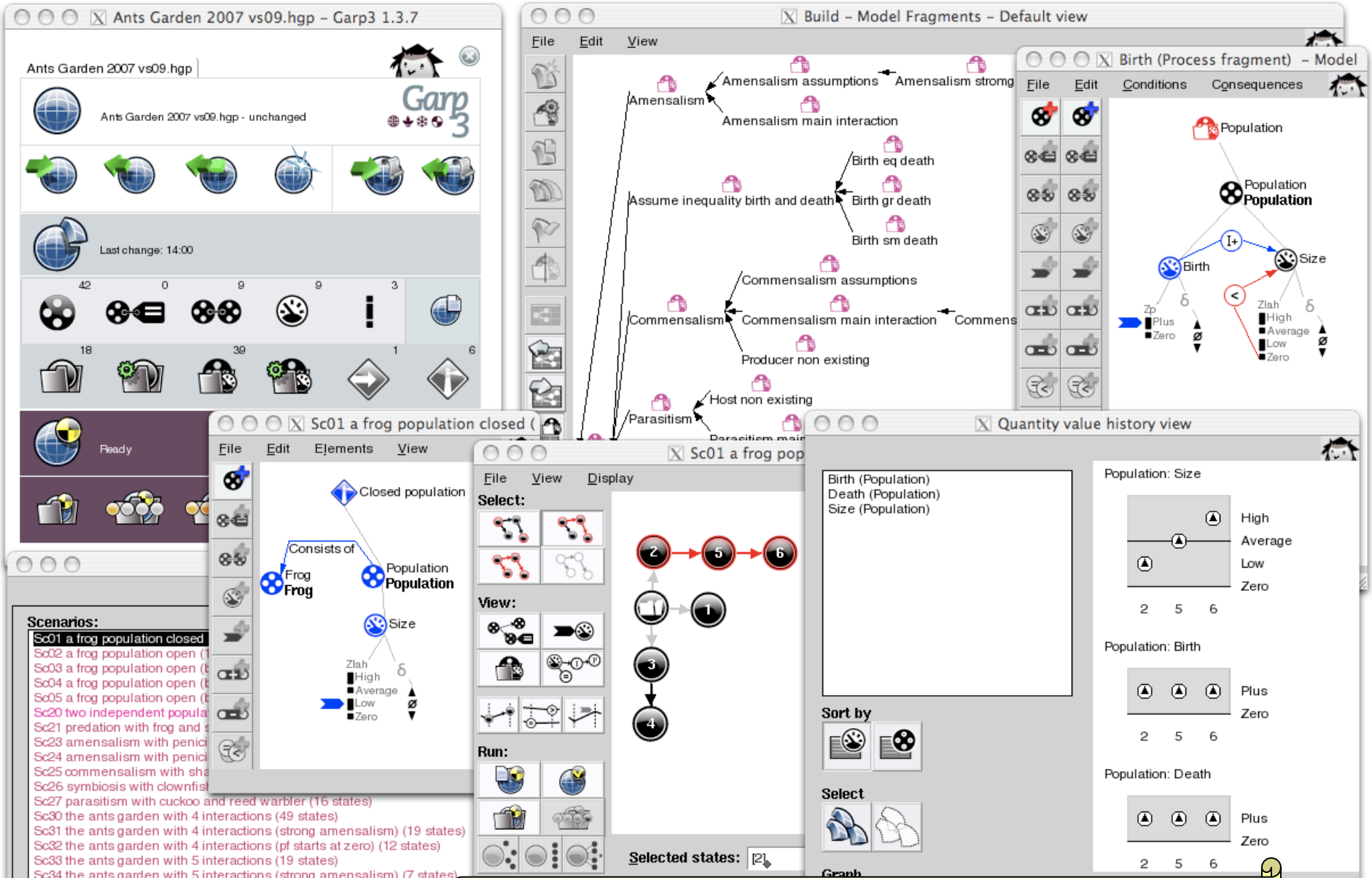
- We say that:
  - An increase (or decrease) in Force causes an increase (or decrease) in Acceleration
  - An increase (or decrease) in Mass causes an decrease (or increase) in Acceleration
- But we do not say:
  - An increase in Acceleration causes …

Learning-by-*conceptual*-modelling

- Modelling is fundamental to human cognition and scientific inquiry (cf. Schwarz & White, 2005)
- Simulations mimic the behaviour of real-world systems.
- Conceptual Reasoning captures the human interpretation of reality:
  - Couched in the appropriate vocabulary
  - Remove numerical 'overhead'
  - Provides handles to automate interaction

Explicitizing the *semantics* of the domain

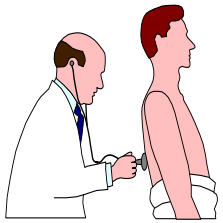
- **Scope**: Which aspects of the system should be included in the model? (relevant/irrelevant)
- **Granularity**: What is the level of detail that should be modeled?
- **Compositionality**: How must knowledge be put in modules in order to allow *knowledge reuse*?
- **Conditionality**: Under what conditions do certain knowledge modules apply?



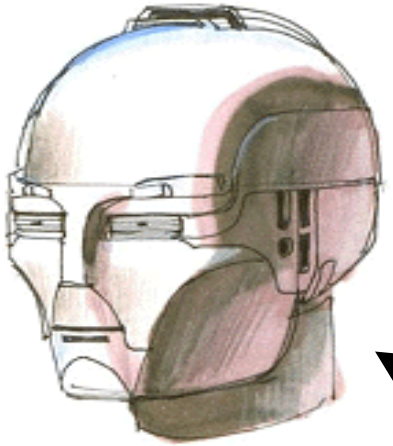
NaturNet-Redime - http://www.garp3.org

Special issue: Ecological informatics, 4(5-6), 2009

Communicative interaction



Supporting domain experts with theory development

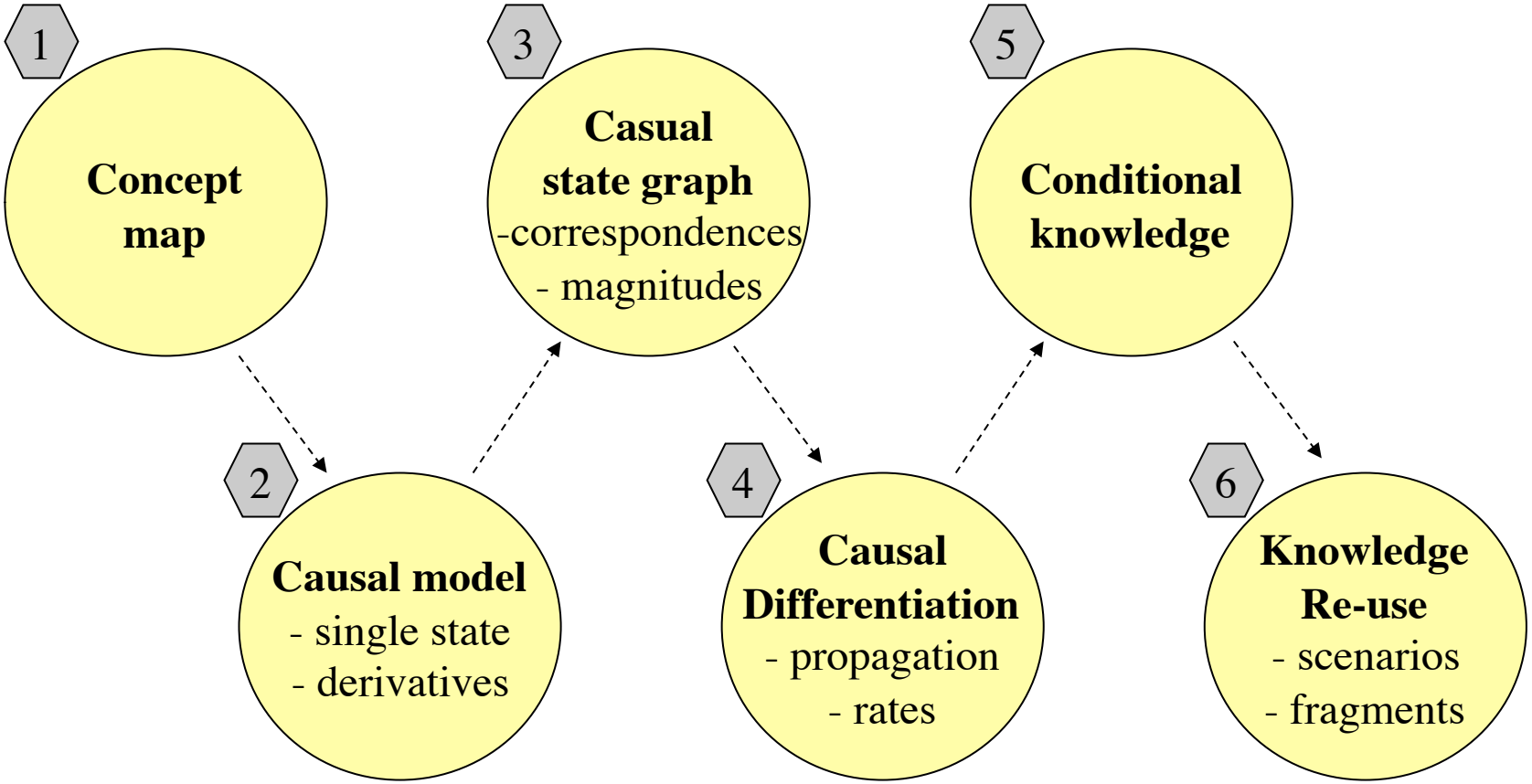


Automated conceptual reasoner

Tutoring & training

Stakeholder management

Learning spaces



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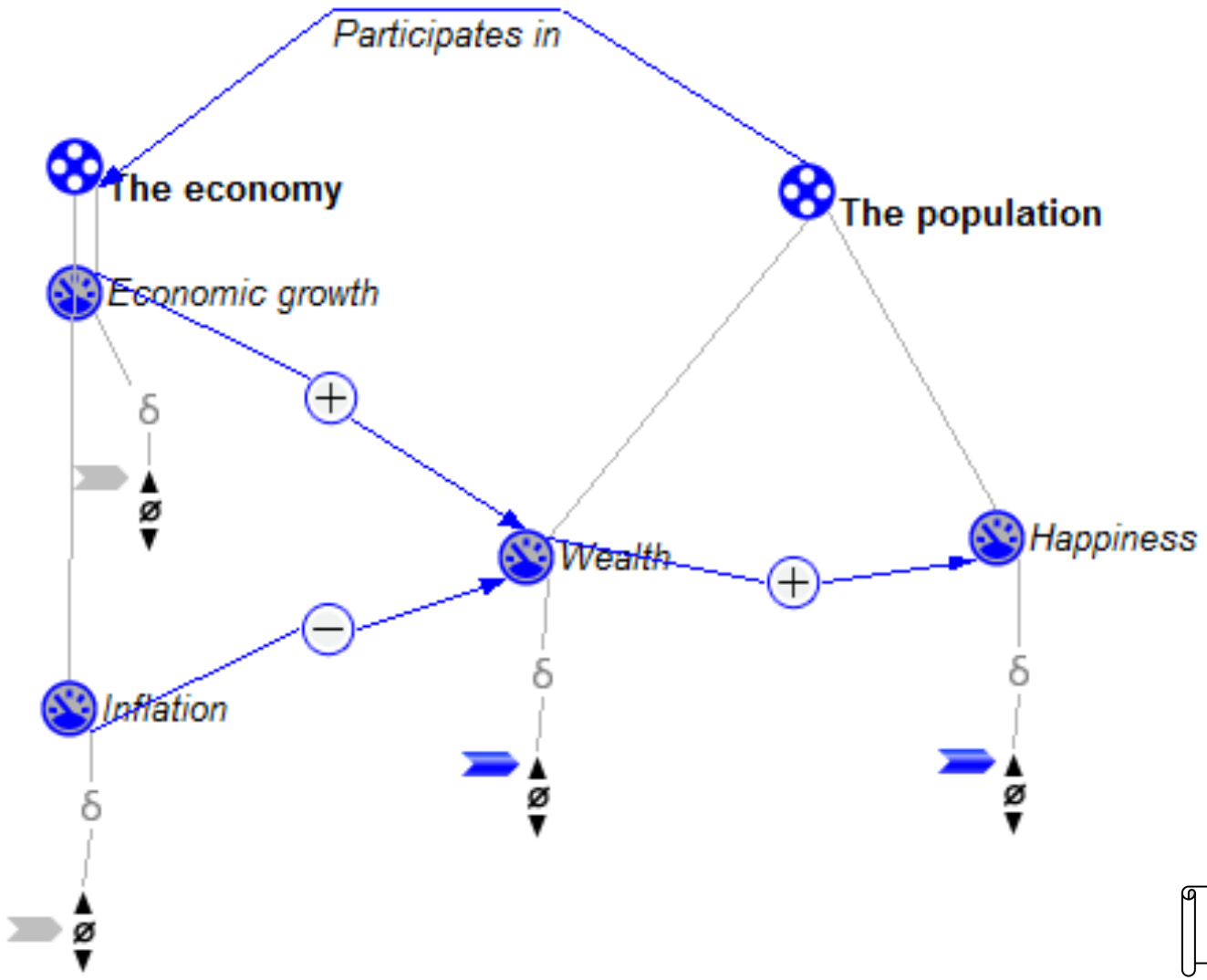
Expressing conceptual knowledge
(learning space 2)



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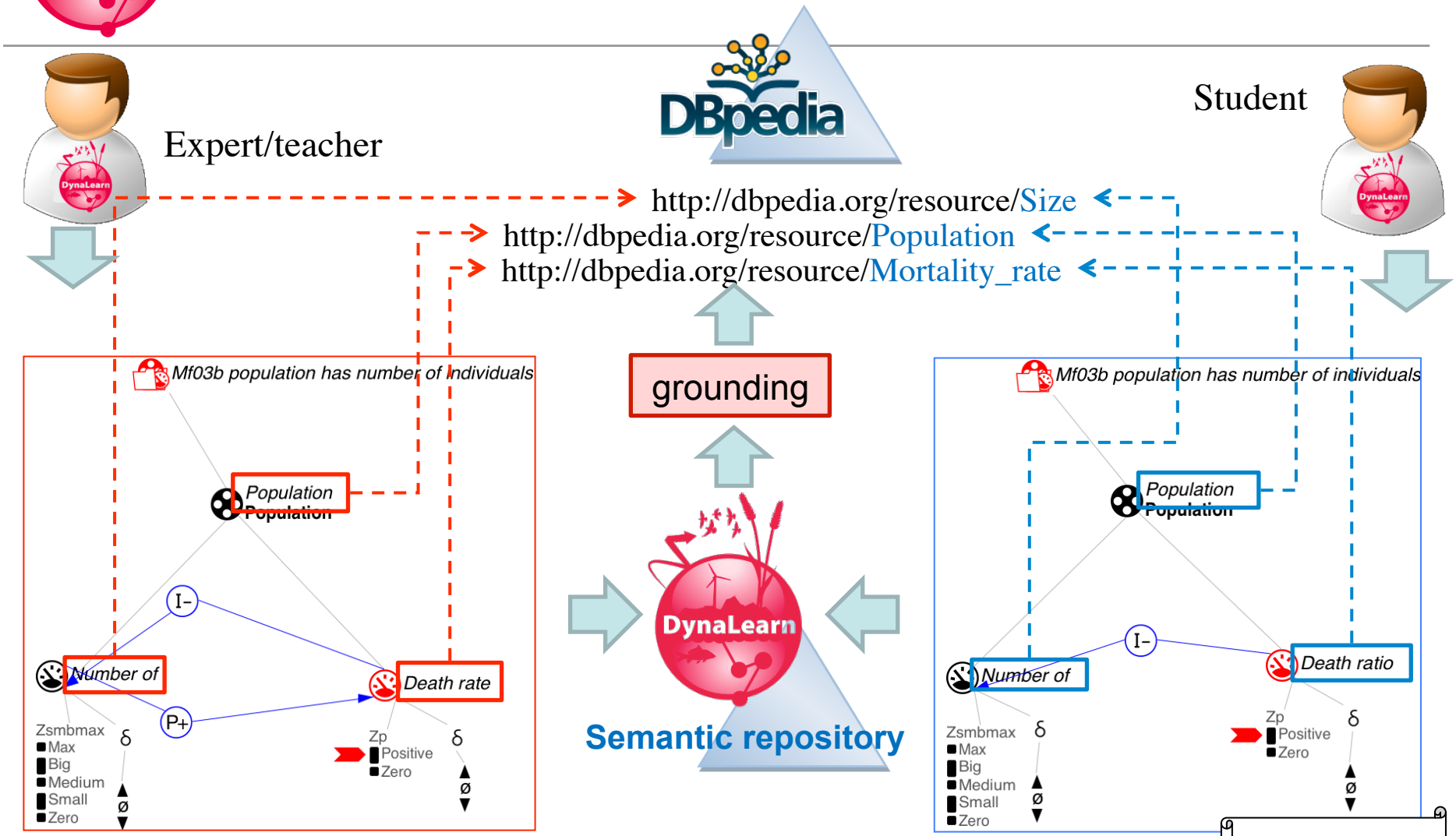
Semantic technology



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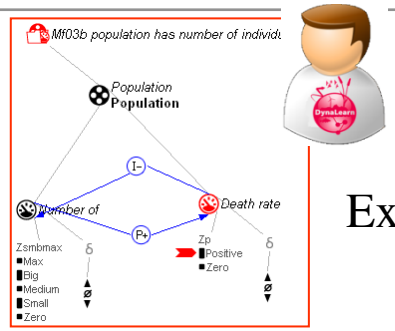
Feedback and recommendation

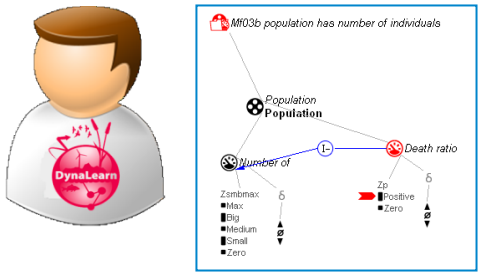
e.g., "You can complete your model with a P+ proportionality"

feedback

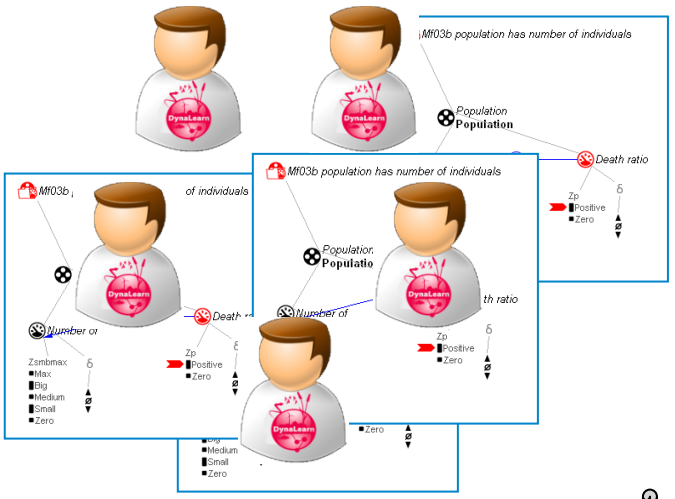


Expert

Student



Community of users



e.g., "Users who modelled death also modelled birth"

recommendations

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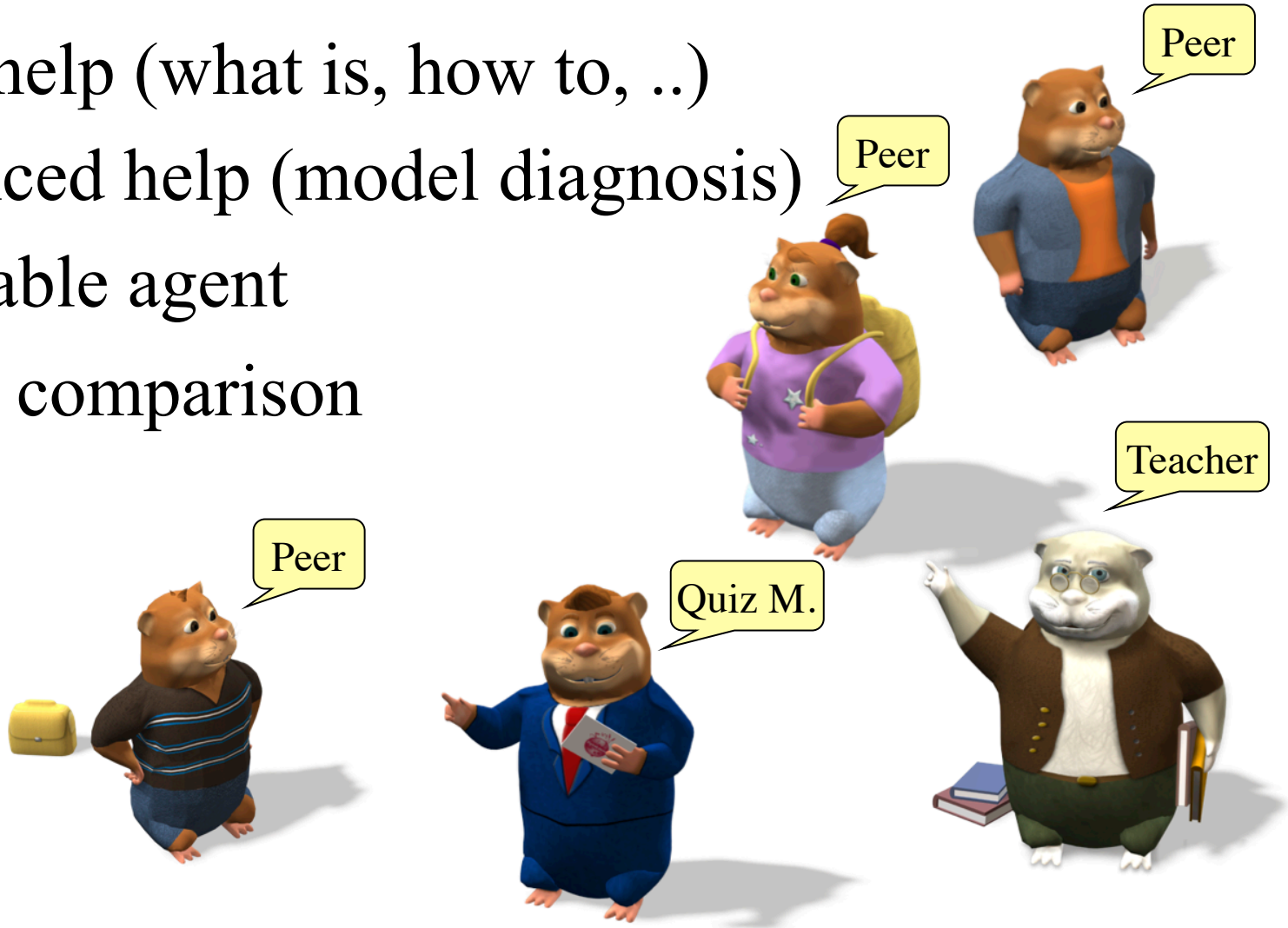
Engaging virtual characters

- Handling complex knowledge
- Handling large amounts of knowledge in a rich vocabulary
- Use different agents for different kinds of knowledge
- Drama-based learning: VCs interacting with the learner and with one another
- Natural Language Generation and Speech Synthesis

Character roles

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



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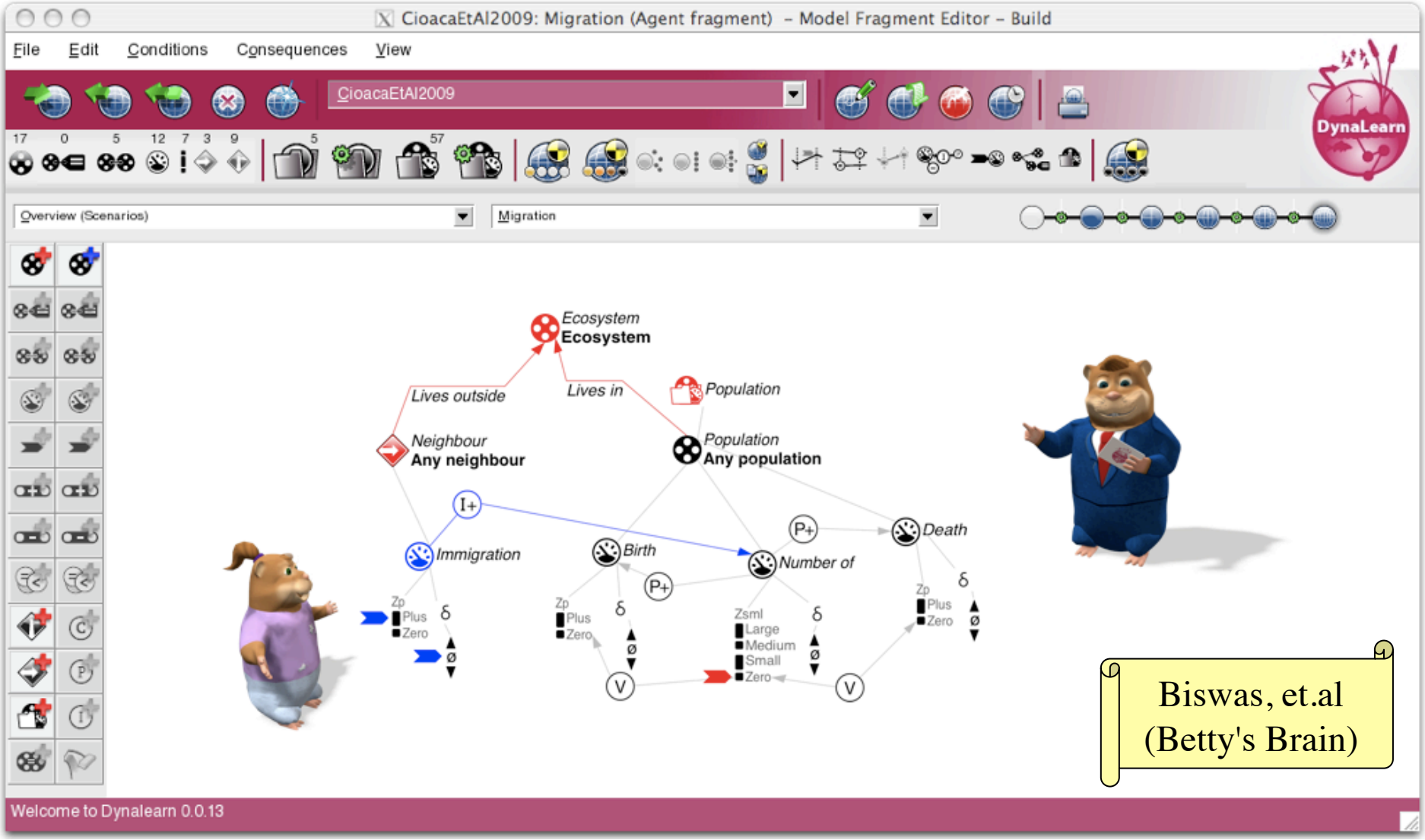
Use case: Teachable agent



Biswas, et.al
(Betty's Brain)

Science curricula

- Interdisciplinary approach: Environmental science
- Rethink the administration of the subject matter
- Establish semantic repository of explanatory models
- Create lesson plans
- Blend in with ongoing classroom learning activities

Project beneficiaries

- University of Amsterdam (UvA - Netherlands)
- Universidad Politécnica de Madrid (UPM - Spain)
- University of Augsburg (UAU - Germany)
- University of Brasília (FUB - Brazil)
- Tel Aviv University (TAU - Israel)
- University of Hull (UH - United Kingdom)
- Bulgarian Academy of Sciences (CLGE - Bulgaria)
- University of Natural Resources and Applied Life Sciences (BOKU - Austria)

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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?
- 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

- 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?

“Call to arms”

DynaLearn is always looking for partners that want to:

- Use DynaLearn in their educational practice.
- Perform their own research using DynaLearn.
- Contribute to enhancing Science Education in any other way.

http://www.DynaLearn.eu

Administrative summary

- Project number: 231526
- Project acronym and title: DynaLearn - Engaging and informed tools for learning conceptual system knowledge
- Starting date: February 1st, 2009
- Duration in months: 36 PMs
- Call (part) identifier: FP7-ICT-2007-3
- Activity code(s) most relevant to the topic: ICT-2007.4.3: Digital libraries and technology-enhanced learning
- Keywords: Conceptual knowledge, Science education, Diagrammatic, representations, Ontology mapping, Virtual characters.

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