Qualitative Reasoning *and* Educational Software Systems

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Bert Bredeweg

University of Amsterdam, Social Science Informatics
Roetersstraat 15, 1018 WB Amsterdam, The Netherlands

Phone: +31 - 20 - 525 6788 / Fax: +31 - 20 - 525 6896

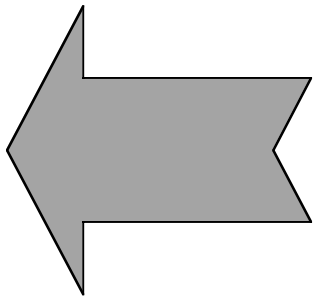
bert@swi.psy.uva.nl

http://www.swi.spy.uva.nl/usr/bert/home.html

Main Message of the lecture

The computer as a knowledgeable agent requires a lot of smart/meta-level indexing of the ‘stuff to be communicated’ in order to address:

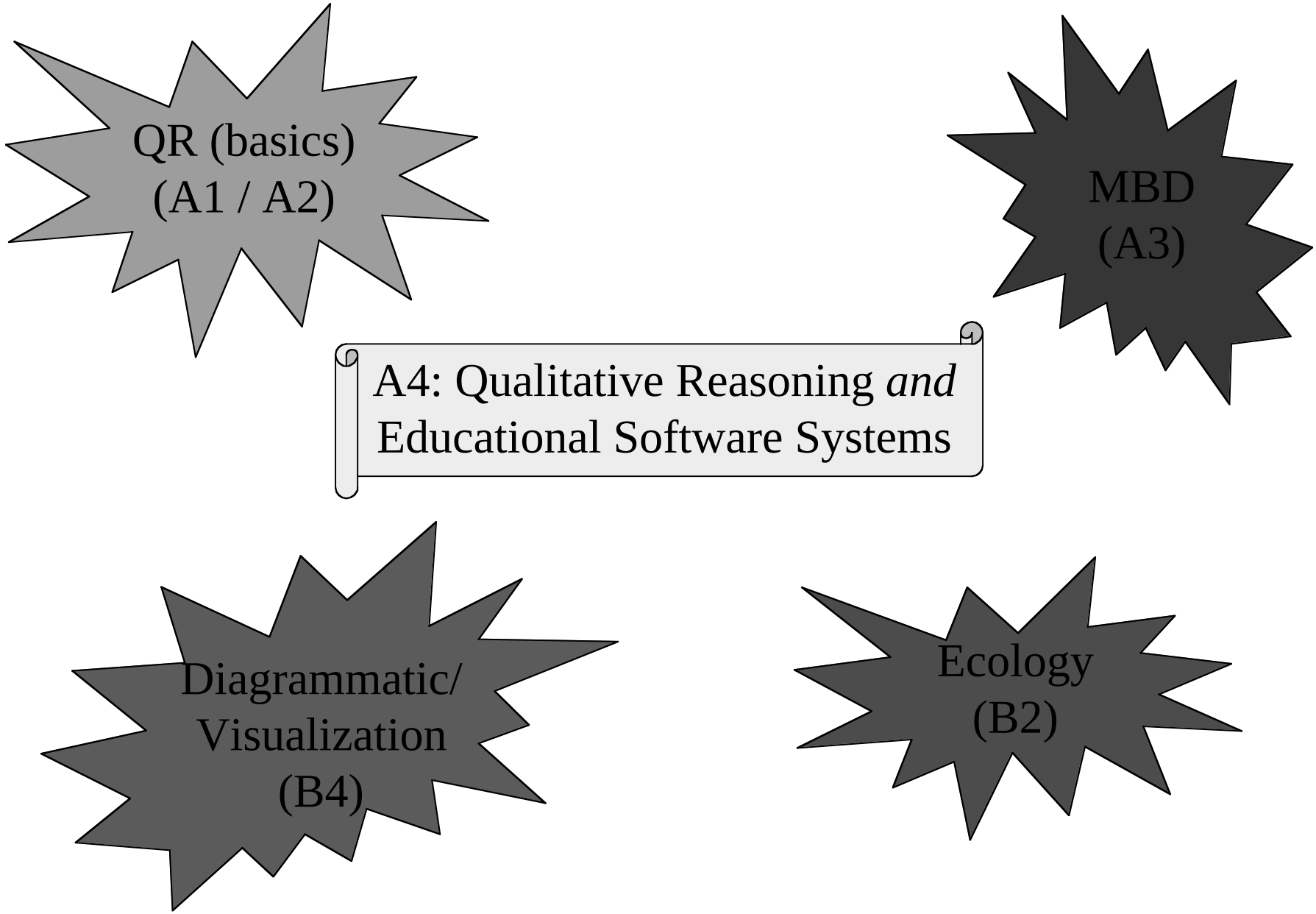
- with whom,
- tell what,
- and in what form.



Qualitative Models & Reasoning

- *What are the issues !*

Notice: relation with other lectures



Overview

- Learning and simulations 
- Research questions
    - Diagnosing learning behaviour
    - Curriculum planning
    - Explanation (incl. visualisation) *(brief)*
- Concluding remarks
- Applications and References *(brief)*

Acknowledgements
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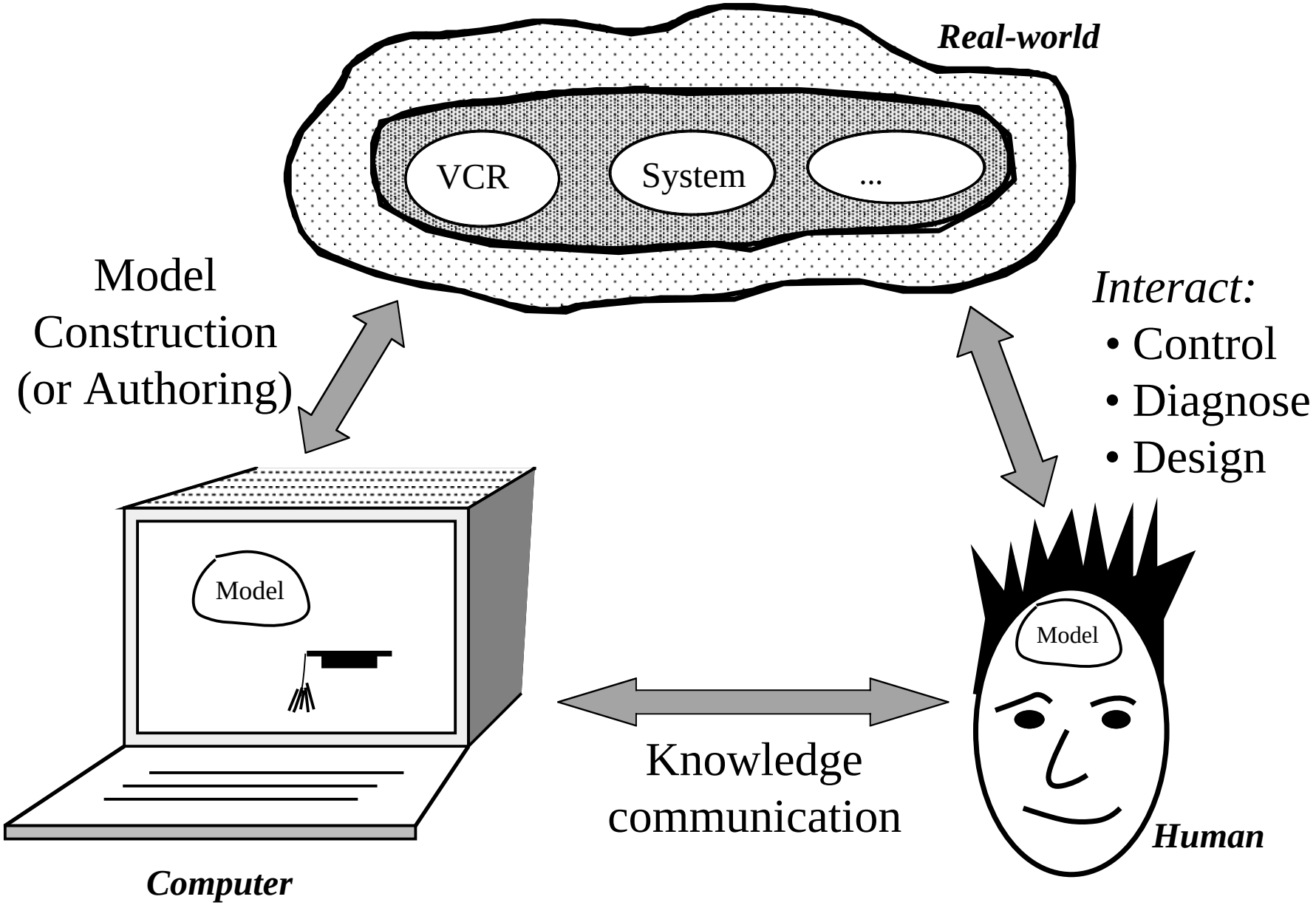
Learning about Systems and Behaviour



Systems…

e.g.

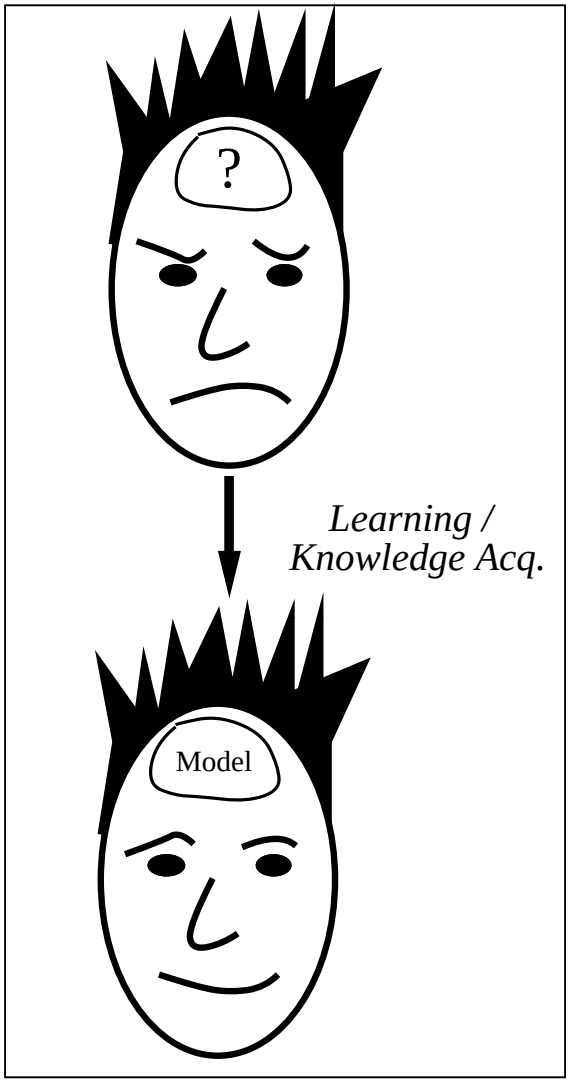
- Medical
- Biological / Environmental
- Physical / Technical (engineering)
- Chemical
- Economical
- …

⇒ STRUCTURE and BEHAVIOUR

Goal

Teach humans to interact with the physical world *(tasks):*

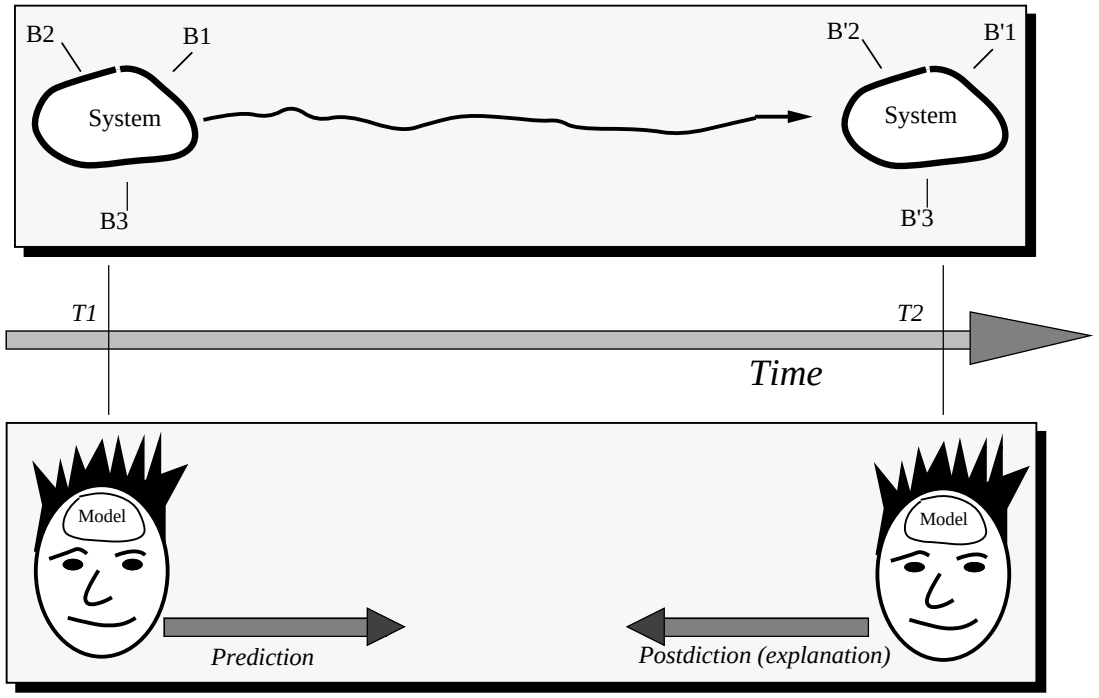
- Control / Operate
- Diagnose / Repair
- Design / Construct
- ...



Basis Idea:

By having humans acquire an appropriate model of (parts of) the physical world

An Appropriate Model ?



Envisioning

(mental simulation)

(e.g. deKleer, 1984)

Requirements ?

- Deriving behaviour from structure
- Causal account
- Domain independent / Re-useable
- Different models for different uses / purposes

How ?

By having humans interact with (tailor-made) computer models

→ Simulations of real-world systems

(but often beyond reality…)

Advantage

- Time translation (fast / slow)
- Costs (x-times)
- Danger (no harm done)
- Impossible world (no gravity on earth)

→ relevant phenomena must be observable

Guidance is Required !

Learning from simulations requires some form of guidance, because of:

- museum problem
- getting lost time

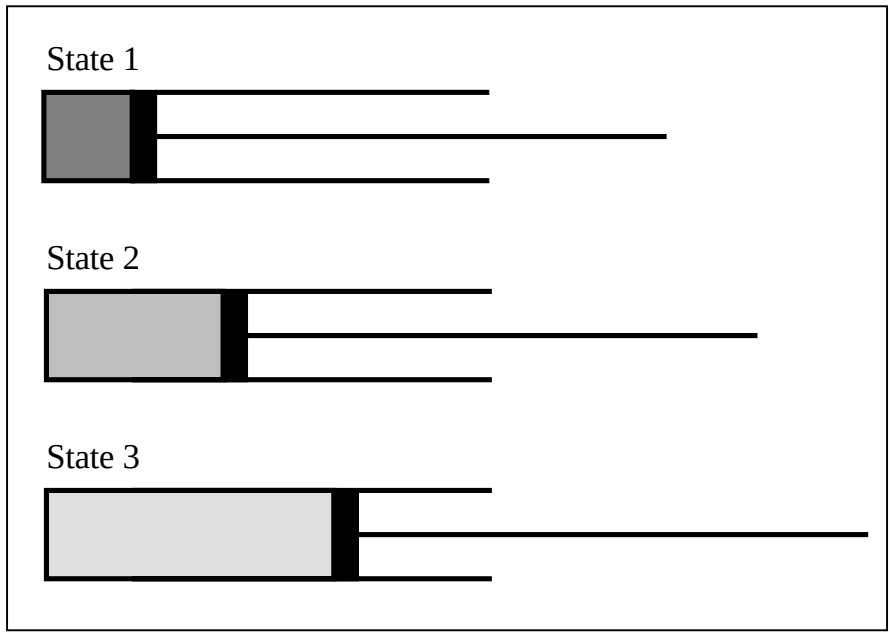
Aspects of guidance *(⇨ teaching functions)*

- adjustment in speed and size/scope
- provide feedback / explanation
- show directions / suggest next step
- …

Requirement

Simulation models must provide handles to facilitate a ‘knowledgeable’ interaction *(⇨ knowledge communication / AI)*

Need for: Articulate simulation models



P.V = n.r.T (Boyle)

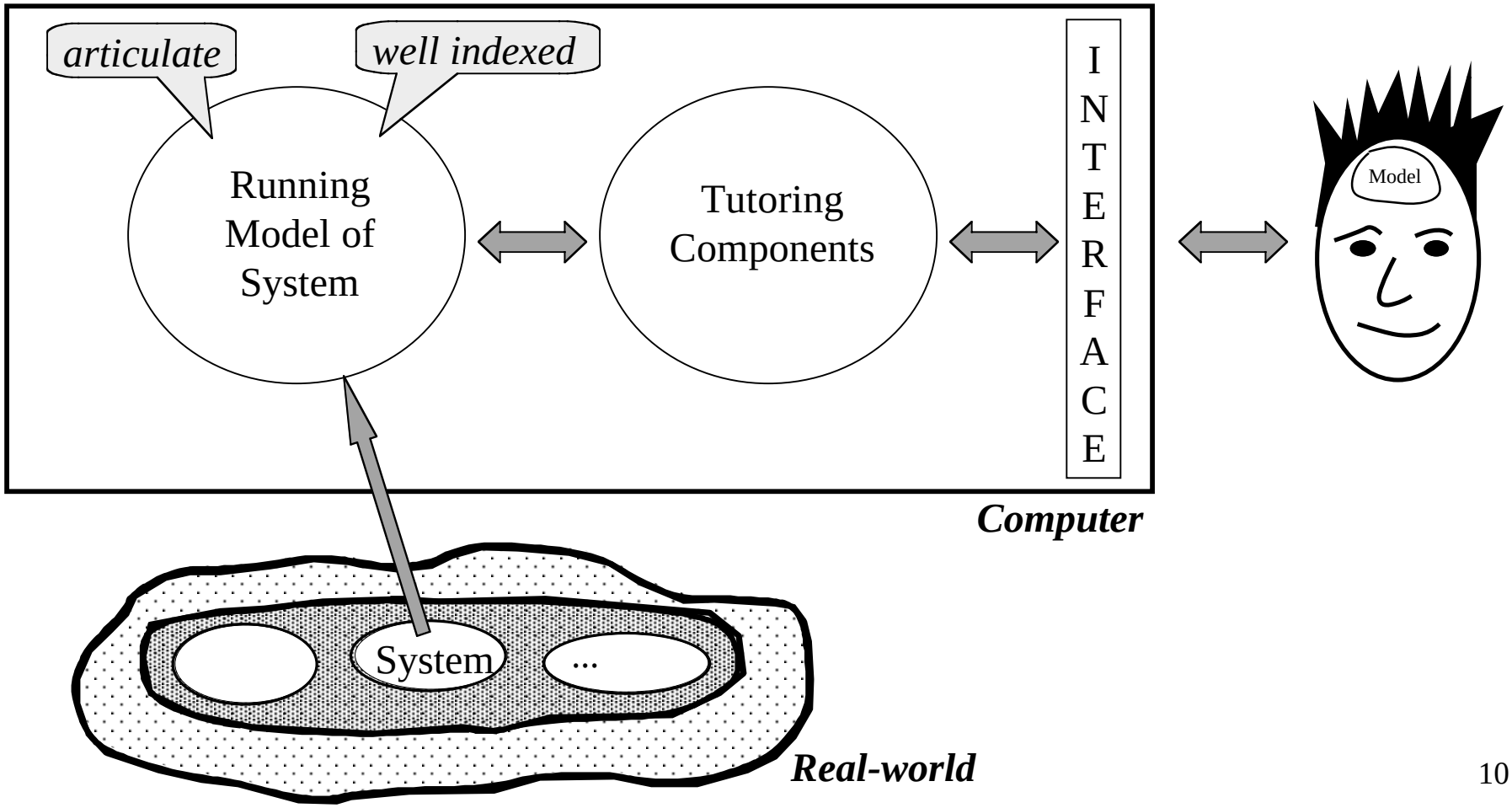
	Volume	**..**	**Pressure**	**..**
State 1	1	..	10	..
State 2	2	..	5	..
State 3	5	..	2	..

≠

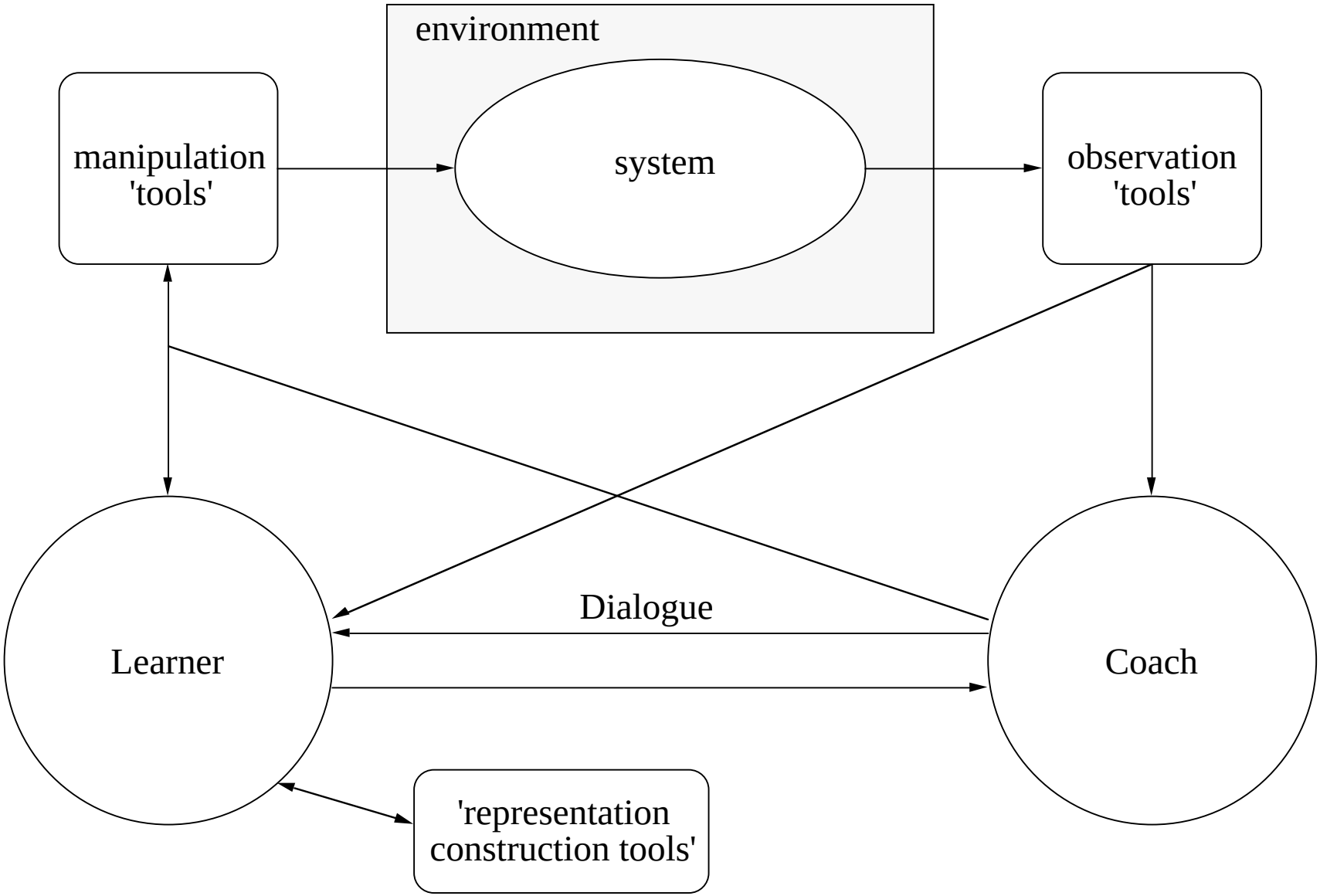
If **V** increases then **P** increases *(e.g. Forbus, 1984)*

Role of Qualitative Reasoning ?

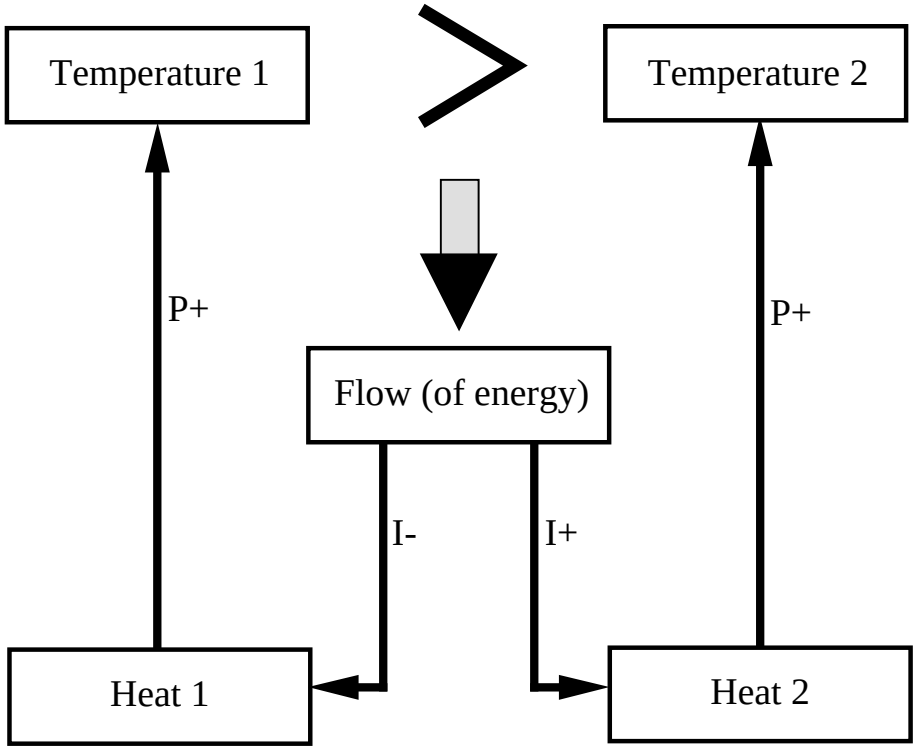
QR provides an ‘ontology’ by means of which computer programs can reason about the behaviour of ‘systems’ such that these computers can communicate about the behaviour of these systems with humans



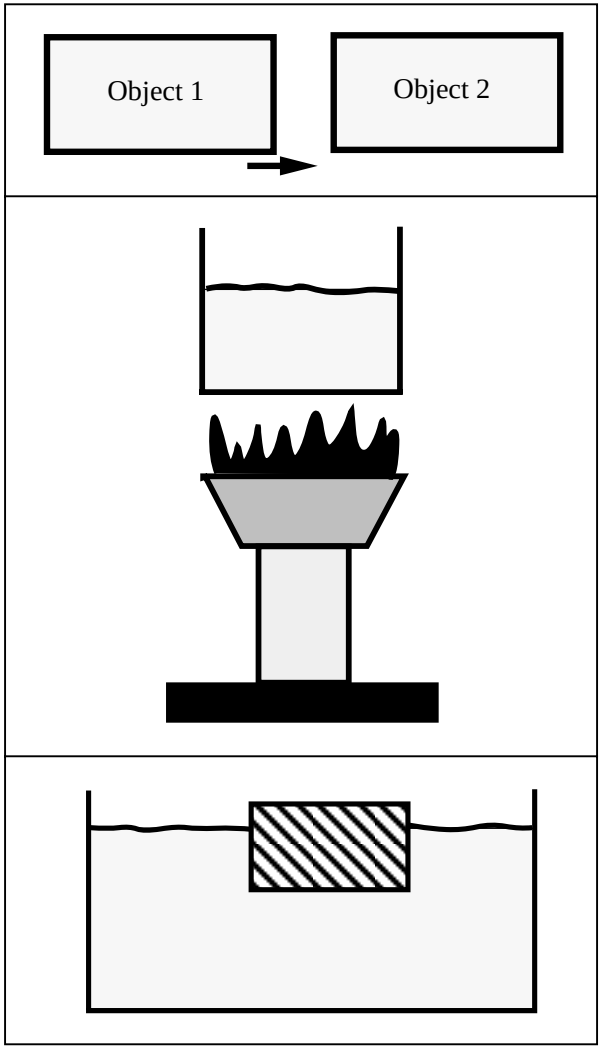
Interactive Learning Environments and Coaching



BUT: Which teaching functions (1)?



E.g. Explanation
***(Heat-flow process**, Forbus, 84)*



- An <u>inequality</u> triggers a <u>flow</u>
- which leads initial changes *(influence)*
- which are propagated *(proportionality)*
- to restore <u>equilibrium</u>.

BUT: Which teaching functions (2)?

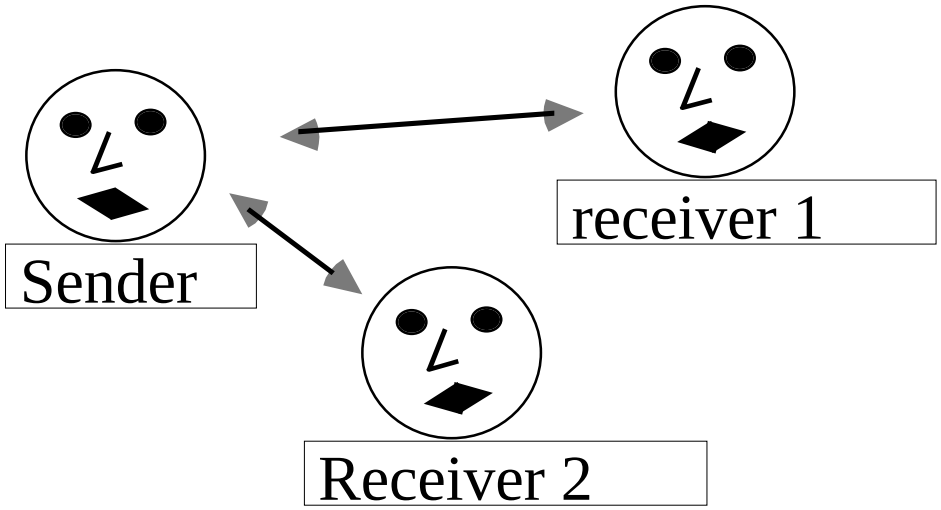
Because the {Obj1:Q1} of {Obj1} is {QuantityCondition}
then the {Obj2:Q2} of {Obj2} a ‘flow’ exists between {Obj1} and {Obj2}
which causes the {Obj1:Q1} of {Obj1} to {Obj1:Q1:∂}
and the {Obj2:Q2} of {Obj2} to {Obj2:Q2:∂}
<if connected props>
In turn, this causes the {Obj1:Q1} of {Obj1} to {Obj1:Q1:∂}
and the {Obj2:Q1} of {Obj2} to {Obj2:Q1:∂}.

Because the {temperature} of {heater} is {greater}
then the {temperature} of {water} a ‘flow’ exists between {heater} and {water}
which causes the {heat} of {heater} to {decrease}
and the {heat} of {water} to {increase}
<if connected props>
In turn, this causes the {temperature} of {heater} to {decrease}
and the {temperature} of {water} to {increase}.

‘Inflexible and probably not exactly what you wanted to hear...’

Knowledge communication (1)

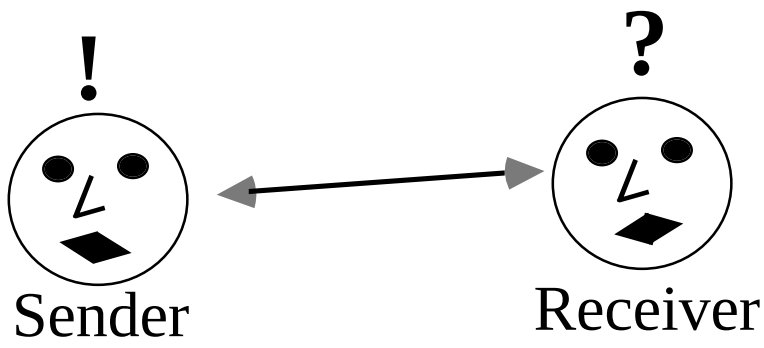
With whom ?



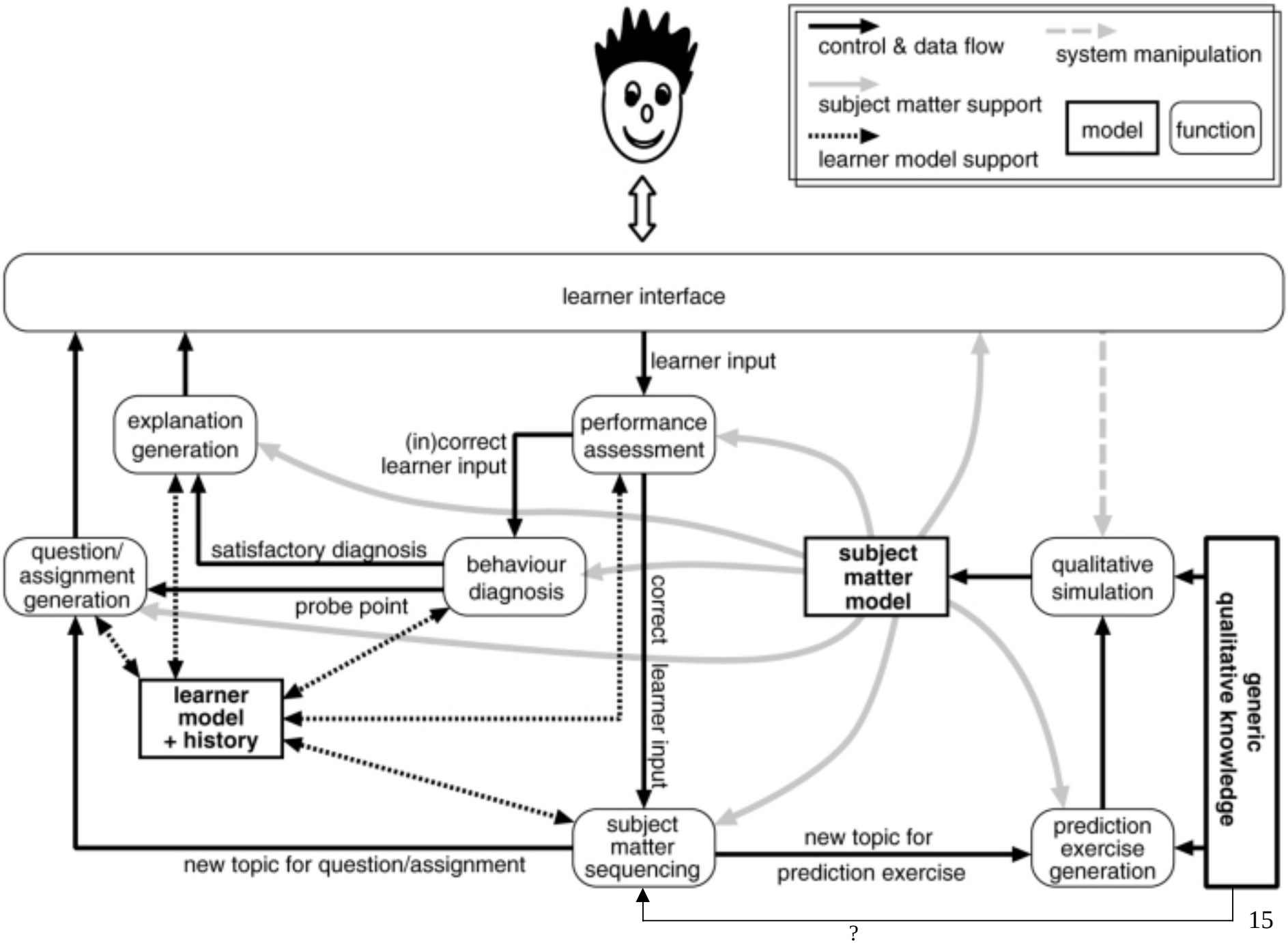
- how to relate to the receiver ?
  - adjust level of detail/expertise
  - use analogies
- does the receiver receive (learn) ?
  - assess response/reaction of receiver
- why does the receiver (not) understand ?
  - diagnose response/reaction of receiver

Knowledge communication (2)

What is the goal ?
How will it be communicated ?



- what does the sender want to ‘communicate’?
- what form should the sender use?
  - question / answer
  - (guided) discovery
- what representations
  - graphics, animations, text,…


control & data flow
system manipulation
subject matter support
learner model support
model
function
learner interface
learner input
explanation generation
(in)correct learner input
performance assessment
question/ assignment generation
satisfactory diagnosis
behaviour diagnosis
probe point
subject matter model
qualitative simulation
generic qualitative knowledge
learner model + history
correct learner input
subject matter sequencing
new topic for question/assignment
new topic for prediction exercise
prediction exercise generation
?

Interactive Learning Environments

Functional units

- qualitative/quantitative simulation
- subject matter sequencing
- (prediction) exercise generation (≈scenario)
- subject matter model
- performance assessment
- behaviour diagnosis
- learner model (construct and store)
- question/assignment generation
- learner interface / visualisation