Empirical Modelling for Educational Technology

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Motivation for paper

Issues for Technology in Education

Making the development of educational software accessible to teachers ...

Enhancing the quality of educational software for learners ...

Propose Empirical Modelling
as a way to meet both these demands

principles of model construction linked to the learning process
=> good educationally

links conception of model to its construction
=> effective in accessible software development

(2)

An Empiricist Perspective on Learning

private experience / empirical / experiential

interaction with artefacts:
identification of persistent features and contexts

practical knowledge:
correlations between artefacts, acquisition of skills

identification of dependencies
and postulation of independent agency

identification of generic patterns of interaction
and stimulus-response mechanisms

non-verbal communication
through interaction in a common environment

phenomenological uses of language

identification of common experience and objective knowledge

symbolic representations and formal languages:
public conventions for interpretation

public knowledge / theoretical / formal

Significance of informal and non-verbal

V Axline

role of non-verbal interaction in psychotherapy

Richard Feynman

physical understanding - unmathematical, imprecise, inexact - absolutely necessary for the physicist

David Gooding

construals in the work of Faraday

Fred Brooks

essence of software is in the requirements capture and specification process

William James

truth of our mental operations as an intra-experiential affair

Thesis behind principles of Empirical Modelling

Appropriate use of computer-based technology liberates the design and construction of artefacts

Principles of Empirical Modelling

Elaborate a model of a phenomenon with reference to a projected causal account ...

Involves systematic identification of

observables

patterns of correlated change to observables ("indivisible relationships")

agents as instigators of state-change

observables that are presumed to account for stimulus-response patterns in agent interaction and their classification with respect to each agent

Leads to the construction of behavioural models, in general partially under super-agent control.

N.B. A single model incorporates an uncircumscribed family of open and closed behaviours

These include:

experimental environments

incomplete models from early stages of development

intrinsic behaviours associated with automatic agents

Causal account: 3 views of agency

Identification of collections of observables with integrity

View 1: attribute agency to all such entities that change state

primitive world-view, cf animism, anthropomorphism

View 2: associate protocols for state-change with View 1 agents

attribute responsibility for change to independent or particular agents

e.g. know what we believe agents are capable of

View 3: ascribe circumscribed stimulus-response pattern to a View 2 agent

predictable wrt observational standpoint and purpose

Pragmatic view of causality

... according to purpose, and perspective

View 1 agency is so broad that vacuous
View 3 agency so circumscribed that redundant

View 3 agency admits formal representation.
Other forms of agency require metaphorical representation.

View 2 agency

Commonsense understanding of systems centres on View 2 agency. Typically

have a good idea of what the relevant agents are

don't have a circumscribed behaviour

have some reliable knowledge about agent capabilities

Need to experiment to understand interaction and behaviour

Empirical Modelling concerned with interfaces between View 1 / View 2 and View 2 / View 3 concepts of agent

Empirical Modelling tools

Definitive (definition-based) notations to express dependency

definitive scripts used to construct perceptual representations of experimental states
cf. 'what if?' of spreadsheet ("1-agent" system)

cf. recipe for understanding causality
'do something and see what happens' (Dennet)

e.g. determine extent of own action (dependency)
identify independent action (agency)

Multi-agent systems

Conceive agents within system as responding to observables that can be metaphorically represented

Can describe the interaction of agents with reference to protocols specified in the LSD notation

oracle potential stimulus

handle
potential observable through which to mediate response

derivate
indivisible relation between observables relative to agent

protocol
repertoire of state-changing actions

state observable bound to the agent

Create computer-based environments in which system state is metaphorically represented (in Abstract Definitive Machine)

Experiment serves to determine

what is reliably true for us

what is true in general rather than particular cases

what is objectively perceived as true

Status of the project

Applications

interactive graphics
design
concurrent engineering
software development
visualisation

Collaborations

British Telecom, IBM, Matra Datavision

Sample models

simulations: vehicle cruise control, traffic lights
physical systems: billiards, room, pendulum
applications: guest-house manager, time-line software
games: OXO, draughts, cricket

Potential implications for educational s/w

Flexible model organisation, evolution and adaptation

- susceptible to super-agent control
- possibility of model combination
- selection of subscripts to serve experimental role
- organisation of scripts e.g. to trace construction process

Distinctive qualities

- state-based approach good for presentation
- can represent viewpoints
  e.g. multiple agencies to monitor interaction
- openness to interaction offers richer scope for CAL
- admits partial, incomplete and inconsistent knowledge
- can adapt to personal requirements

Specific educational applications

1) Construction of models to illustrate
   a particular process / device / concept

   encourages openness and the possibility for interaction
   and extension that has not been preconceived

2) Basis for a construction kit

   potential for re-use fundamental & flexible (cf. OO)
   can have library of gadgets, objects, environments etc

3) Presentation tool for exposition of material

   proof presentation
   animation of stages in understanding complex system
   program construction

Content of Talk

Concluding Remarks

Empirical Modelling potentially offers insight into learning process

- model construction assists understanding of application
- understanding of application informs model construction

Process has to be experienced to be appreciated

Has been demonstrated in many projects with wide applications

Plans for pilot project with UK schools in 1997-8

Further info available via website of Empirical Modelling Project

http://www.dcs.warwick.ac.uk/pub/research/modelling