Student Models:
Theoretical Perspectives and Instructional Design Paradigms

By Tina Leard – February 2001

- Establish the need for student models.
- Examine advantages and disadvantages of modelling students.
- Review theoretical perspectives used to interpret student models for the purpose of instructional design.
- Explore instructional design strategies based on student modelling.

Establish the need for student models

In the field of educational technology, artificial intelligence means interpreting the student's interactions and then responding accordingly.

For the system to act intelligently, it must generate a student model.

What are student models?

- Representation that the observer uses to understand the learner.
- Student modelling refers to techniques that enable an instructional system to understand the learner.
- Learner models can represent what the learner understands, misunderstands, and needs.

Student Models by Tina Leard – February 2001

Advantages and disadvantages of modelling students

Advantages of Student Models

Personalization:

Cognitive diagnosis.
Individual differences cannot be anticipated at design time.
Traditional systems may provide variety that may match learners' needs, but this variety is not necessarily catered to the individual.

Guided navigation:

Adapt sequence of instruction according to what nodes are visited and when.
Present links based on previously visited nodes and responses in exercises.
Traditional systems do not adapt links; navigational design is static.

Adaptive feedback:

Provide remediation during exercises based on individual interactions.
Traditional systems provide feedback on the basis of the question at hand rather than a sequence of interactions.

Complex coaching and scaffolding:

Based on particular difficulties encountered by the student.
Bridges the gap between the student's input and some conception of correct knowledge, such as an expert model.
Traditional systems provide coaching and scaffolding on the basis of one input whereas an intelligent system considers several inputs.

Disadvantages of Student Models

Inadequate modelling by computers

Models may be vague or incomplete. The system would need to be able to trace and interpret every interaction for the model to be almost complete. The model is never complete because the learner's interactions with the computer do not necessarily represent every interaction in the learning situation. Furthermore, it is often assumed that these interactions represent learning processes, which may not be the case.

Better more cost-effective alternatives

Another problem is that interactions may not be representative of learning. For instance, the learner may be tired and may perform poorly in an exercise. Or, perhaps the learner is unclear of how to complete the exercise. The system may infer that the learner has not mastered the content and present certain aspects of already covered material to the student. In this case, adaptive feedback would be ineffective.

Theoretical Perspectives

> The issue should not be
> "To model or not to model,"
> but *who* or *what* does the
> modelling and coaching in a
> particular learning situation:
> computers or human beings?
>
> Susanne P. Lajoie
> *Computers as Cognitive Tools,*
> *Volume Two: No More Walls* (2000)

Three camps of modellers:

1. Modellers
Model students' thinking processes by tracing their interactions and then responding intelligently.

2. Non modellers
Believe that computers cannot be responsible for student modelling. Suggest that students can be stimulated to monitor and diagnose their own learning through cognitive tools and assistance from peers or human tutors.

3. Middle campers
Emphasize the use of cognitive tools within computer-based learning environments that help learners in the context of problem solving.

Student Models by Tina Leard – February 2001

Interpreting Student Models

Tracing learners' interactions yields a type of observational data. This observational data must be interpreted from a theoretical perspective so that it can be compared to an expert or domain model.

Theories

Self-Regulating Learning

Students apply different tactics for different goals.
Dynamic process whereby learners select, adapt, and generate learning tactics.
Four phases: task understanding, goal setting and planning, enacting study tactics, and metacognitively adapting studying.

Situated Cognition

Action is grounded in the situation in which it occurs.
Knowledge is task dependent.
Learning must occur in complex social environments.

Activity Theory

Mind and body are interrelated, so knowing is interpreted in the context of doing.
Activity is a precursor to learning.
There is a reciprocal regulatory feedback between knowledge and activity.
Focusses on learner engagement, tool usage, social and contextual relationships amongst collaborators, the goals of the activity, and the outcomes of the activity.

Instructional Design Strategies

Designing an Intelligent System

Once the designer has established theories to interpret student models, instructional design strategies must be addressed. An intelligent system contains three models that interact:

1. Domain or Expert Model

   Created through cognitive task analysis or simply a task analysis.
   Considers domain structuredness (cognitive flexibility theory).
   Considers domain complexity.

2. Student Model

   Created through interpretation of interaction traces.
   Represents understanding, misunderstanding, and the needs of the student.
   Considers domain and task complexity.

3. Instructor Model

   Grounded in learning and instructional design theories.
   Includes coaching and scaffolding (cognitive apprenticeship), as well as adaptive feedback.
   Includes adaptive presentation of content.

Establishing Interaction Rules

- Decide how to represent the domain or expert model.
- Decide how to compare student model to domain model.
- Decide how the system responds through the instructor model.

Building a Student Model

- Navigation paths
- Content accessed
- Tools accessed
- Type of node
- Responses in exercises
- Contents of typed entries
- Collaborative communication