Artificial Intelligence in Education - the next 10 years

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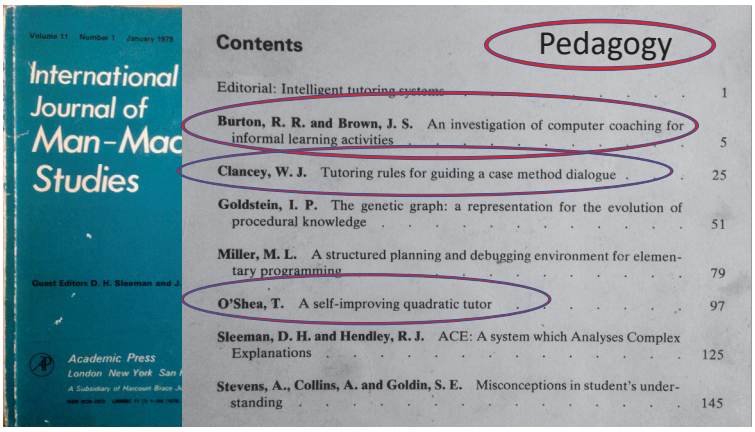
Contents

More active reflective learning

1. Early Days AIED



Explicit Pedagogies

West

Principle 6

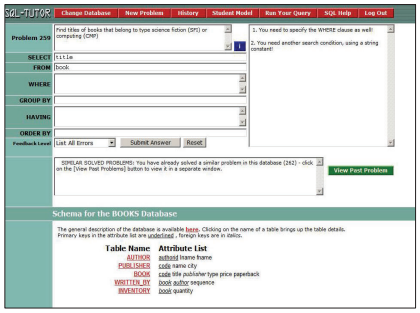
Do not tutor before the student has a chance to discover the game for herself

Mycin -> Guidon

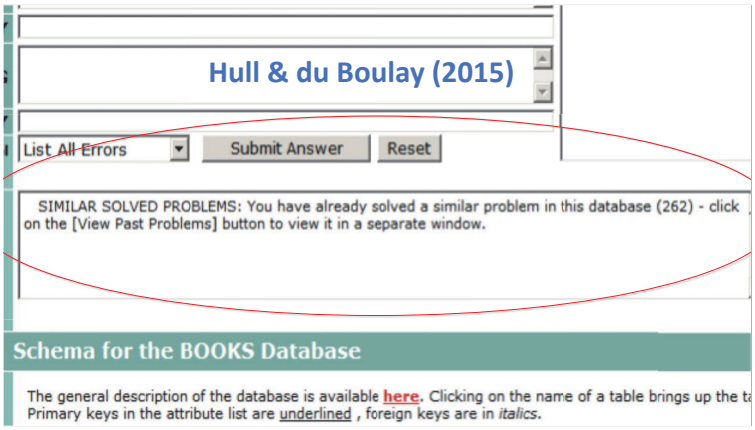
- D-Rules
- T-Rules

2. Screen-level and Deployment Level

Screen-level Pedagogy



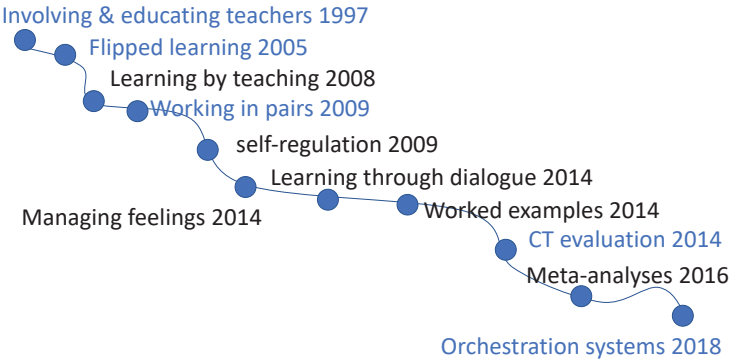
Deployment-level Pedagogy



Deployment-level Orchestration (Dillenbourg, 2013)

"At an abstract level, orchestration is a regulation process similar to adaptive (individualized) instruction: monitoring the situation, deciding what adaptations are necessary and then performing these adaptations. In adaptive instruction, however, this loop is rather closed. In orchestration, on the other hand, the loop is very open . . ."

Developments of Active Pedagogy



3A. Deployment Level Examples

Andes: VanLehn et al. (2005) Deployment for Homework

5 cohort years
Homework + Andes *vs.* homework no Andes

Overall effect size 0.61

Cognitive Algebra Tutor: Koedinger et al. (1997, 2016)

Deployment strongly involving teachers

Pane, McCaffrey & Karam (2014) Cognitive Tutor Algebra

No. of Schools	Comparison	Effects	But . . .
73 high 74 middle Across 7 USA states	Post-tests using traditional teaching	First year not significant. Second year high schools significant. Effect size 0.20	No direct monitoring of how the system actually used

Deployment makes a difference

Walker et al. (2009): Deployment – Peer Tutoring Pairs

- **Support**
  - **Adaptive**
  - **Non-adaptive**
  - **None**

Walker et al. (2009): Deployment – Peer Tutoring Pairs

- Collaboration -> more efficient learning
- Tutor in pair sometimes benefited more than tutee in pair

Lumilo: Holstein et al. (2018)

Deployment Level Pedagogy – ways forward

- Orchestration class systems (FACT: Cheema et al. 2016)
  - Teacher interface for trigger issues
  - Managing/creating/interjecting in pairs and groups
    - Simulated peer student (e.g. Vizcaino & du Boulay, 2002)
  - Intercommunicating with cohort systems (e.g. Course Signals at Purdue)

3B. Screen-level Examples

Worked-Examples vs Problems: Najar et al. (2016)

Alternating worked-example, faded worked-examples and problems.

Adaptive vs fixed sequence

Adaptive better

Betty's Brain (Leelawong & Biswas, 2008, 2016): Screen-level pedagogy

- **Learner agency**
- **Metacognitive feedback**
- **Basic reasoning skills**

MetaTutor (Trevors, Duffy, Azevedo, 2014)

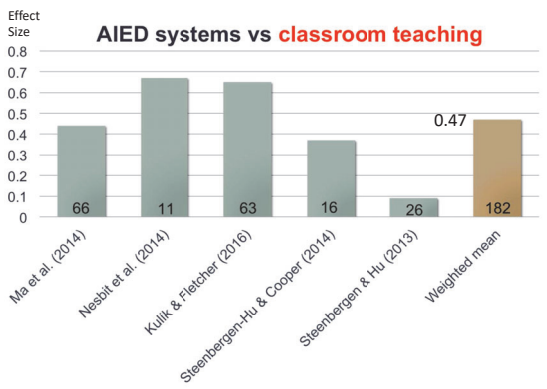
"Models, prompts and supports self-regulatory Processes" via pedagogical agents

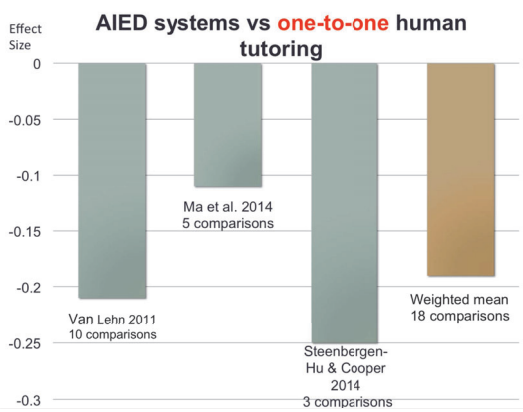
MetaTutor (Trevors, Duffy, Azevedo, 2014)

Decreased quantity of shallow note-taking but not increase quality

Arroyo et al. (2014) Wayang Outpost

Student State	Cognitive Decision	Affective/Meta-cognitive Decision
Mastery without effort	Increase Problem Difficulty	Show learning progress
Mastery with high effort	Maintain problem difficulty	Affective feedback: praise effort
Hint abuse, low effort	Reduce problem difficulty	De-emphasise importance of immediate success
. . .	. . .	. . .





-0.19

Screen-Level Pedagogy - ways forward

- Initial and final interaction
  - Volition
  - Path through material
- Developing in-session pedagogy via analytics

Volition – the will to learn (Keller, 2008)

Coach Mike: Lane et al. (2013) “salesman”

Coach Mike – How was that for you?

SOLA

SOLA*: Arshad et al. (1993)

Top Down
124
125
126
137
138

Bottom Up
421
521
621
731
831

Improving pedagogy via analytics

1. Removing specific pedagogic bugs
2. Determining macro-adaptive parameter values
3. Using machine learning to induce pedagogic tactics

Human in the loop

4. Self-improving tutoring
   - At various topic and temporal granularities
   - Linked to orchestration systems

Removing a specific tutoring bug (Koedinger et al., 2013)

Geometry Tutor – particular skill not sufficiently de-composed

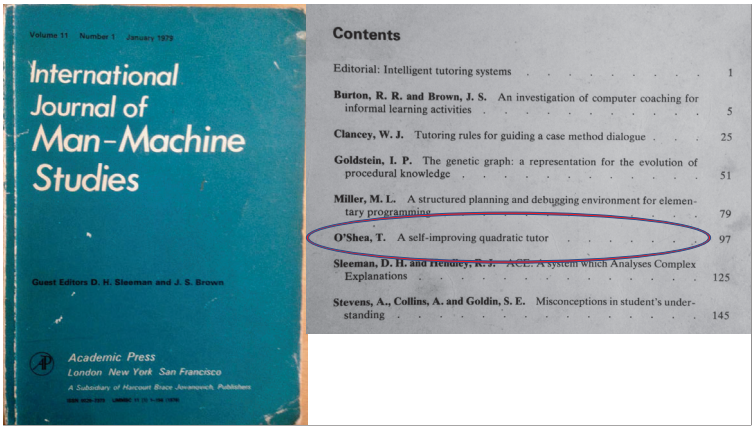
Arroyo et al. (2000) Macro-adapting AnimalWatch

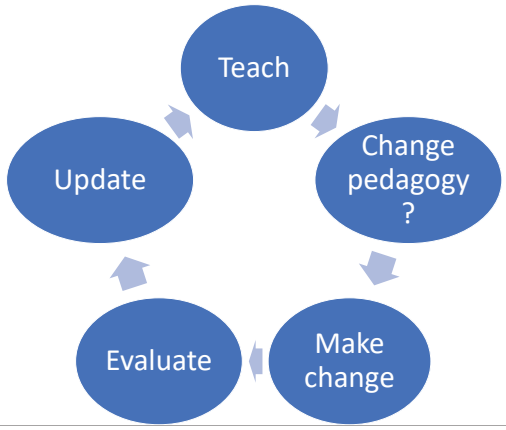
		Hint characteristics	
		Interactivity	Symbolism
Learner Variables	Gender		
	Cognitive development		

". . . boys benefit better from non-interactive and low-intrusive hints, while girls benefit better from highly interactive hints."

Chi et al. (2011) Inducing pedagogic tactics

"whether the student is told what principle to apply or whether the system elicits it with a prompt, and whether a student, once he/she has made a step, is asked to justify his/her answer."





Meta-pedagogy: "theory of instruction" how *changes* in pedagogy produce *changes* in outcomes

- Possible goals:
  - Increase post-test scores
  - Decrease learning times
  - . . .
- Theory:
  - Shorten the sessions *will certainly* decrease learning time
  - Shorten sessions *may possibly* decrease scores
  - . . .

Conclusions

- Screen-level & Deployment level pedagogy
- AI as an effective teaching *assistant*
- Teachers central, but need support
- Learners are human
- Fostering the will to learn

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