Artificial Intelligence in Education - the next 10 years

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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

Involving & educating teachers 1997
- Flipped learning 2005
- Learning by teaching 2008
- Working in pairs 2009
  - self-regulation 2009
  - Learning through dialogue 2014
- Managing feelings 2014
- Worked examples 2014
- CT evaluation 2014
- Meta-analyses 2016
- Orchestration systems 2018

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

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. Vizcaíno & du Boulay, 2002)
- Intercommunicating with cohort systems (e.g. Course Signals at Purdue)
3B. Screen-level Examples

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

<table>
<thead>
<tr>
<th>Student State</th>
<th>Cognitive Decision</th>
<th>Affective/Meta-cognitive Decision</th>
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<tbody>
<tr>
<td>Mastery without effort</td>
<td>Increase Problem Difficulty</td>
<td>Show learning progress</td>
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<tr>
<td>Mastery with high effort</td>
<td>Maintain problem difficulty</td>
<td>Affective feedback: praise effort</td>
</tr>
<tr>
<td>Hint abuse, low effort</td>
<td>Reduce problem difficulty</td>
<td>De-emphasise importance of immediate success</td>
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Worked-Examples vs Problems: Najar et al. (2016)
- Alternating worked-example, faded worked-examples and problems.
- Adaptive vs fixed sequence
- Adaptive better
**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”

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**COACH MIKE**

How was that for you?
Improving pedagogy via analytics

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

Arroyo et al. (2000) Macro-adapting AnimalWatch

<table>
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<tr>
<th>Learner Variables</th>
<th>Gender</th>
<th>Cognitive development</th>
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</thead>
<tbody>
<tr>
<td>Interactivity</td>
<td></td>
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<tr>
<td>Symbolism</td>
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“... 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
References for du Boulay Keynote

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