Dynamic Problem Solving:
A computer-based perspective for large-scale assessments

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Dynamic Problem Solving
A computer-based perspective for large-scale assessments
University Heidelberg

- A) Dynamic Problem Solving & CBA
- B) How to measure DPS - old & new ideas
- C) MicroDYN & MicroFIN
- D) Scaling and validity
- E) Extensions of DPS in CBA
- F) Possibilities & challenges
A) Dynamic Problem Solving & CBA I

- DPS as major field in experimental research over the last decades.
- Little research in the context of individual differences (for first efforts see Beckmann & Guthke, 1995; Wagener, 2001).
- In large-scale assessments growing interest in cross-curricular competencies.
- DPS as potentially valuable aspect of school achievement (Klieme, Leutner & Wirth, 2005).
A) Dynamic Problem Solving & CBA II

• “A central feature [...] is a focus on tasks that require direct interaction by the solver to uncover and discover relevant information in order to successfully solve the problem. Such problems are categorised as “interactive or dynamic”, and differ markedly from “static” problems”

(excerpt PISA Problem Solving framework 2012)
A) Dynamic Problem Solving & CBA III

- **DPS requires**
  - Interactive communication between task and problem solver
  - Includes facets measured by continuous data streams
  - Needs to be assessed computer-based
- **A construct NOT measurable by traditional means (paper-pencil)**
- **DPS is not supported by CBA but relies on it**
- **Software development in over 10 cycles since May 2008**
### Erkunde das Labor

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<tr>
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<tr>
<td>C 0</td>
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Akt. Runde: 13

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Erreiche den vorgegebenen Zielbereich in höchstens 4 Schritten!

Modell:

- UV A
- UV B
- UV C

- AV 1
- AV 2
- AV 3

Kantenwerte:

- +1
- -1

Runde 5

85
B) How to measure DPS I

- 3 ways to measure DPS
  - (1) Microworlds
    - Early in literature; extremely complex
    - Examples: Tailorshop, Lohhausen
  - (2) Formal systems
    - Introduced in the 80s by Funke
    - As answer to problems with Microworlds
  - (3) Minimal complex systems
    - Currently developed in Luxemburg & Heidelberg
    - Formal systems under consideration of psychometric aspects
    - MicroDYN & MicroFIN
B) How to measure DPS II

- Suggested categories for problem types

```
Problem type
  /     \\
//       \\
Static- Dynamic
      /       \\
//         \\
Closed - Open-ended
            /       \\
//          \\
Tasks constructed ad hoc - Tasks embedded into generic framework
                  /          \\
//                \\
Linear equations: MicroDYN - Finite automatons: MicroFIN
```
B) How to measure DPS III

- Dörner’s Theory of Operational Intelligence (1986)
- Theoretical foundation is obtained
- Different facets of DPS are measured (multidimensional construct)

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<td>Priority setting and evaluation</td>
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C) MicroDYN & MicroFIN I

Diagram:

- $X_1$ to $Y_1$: main effect
- $X_2$ to $Y_1$: multiple effect
- $X_3$ to $Y_3$: multiple dependence
- $Y_1$ to $Y_3$: eigendynamic
- $Y_2$ to $Y_3$: side effect

Exogenous variables: $X_1$, $X_2$, $X_3$
Endogenous variables: $Y_1$, $Y_2$, $Y_3$
C) MicroDYN & MicroFIN II

- **(A) Stage 1:**
  - „Explore the system.“
  - 180 seconds
  - Information retrieval

- **(B) Stage 2:**
  - „Draw the connections between variables as you suppose.“
  - Simultaneously to (A)
  - Model building

- **(C) Stage 3:**
  - „Reach given target values on the endogenous variables by entering correct values in the system.“
  - 60 seconds
  - Forecasting

*Several independent items are presented

*Scaling possible!*
C) MicroDYN & MicroFIN III

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Schmetterlinge


Finde heraus, wie Wildranke, Blassblatt und Sonnengras mit Rotschwärmern und Blauschwärmern zusammenhängen. Trage deine Vermutungen in das Modell ein!
Butterfly

Wildranke
--- o + ++

Blassblatt
--- o + ++

Sonnengras
--- o + ++

Hilfe
Alles löschen
Ausführen!

Runde 12
157

Rotschwärmer
20

Blauschwärmer
5

Modell

Wildranke
Blassblatt
Sonnengras

Rotschwärmer
Blauschwärmer
Du hast den ersten Teil der Aufgabe beendet!


Wie musst du Wildranke, Blassblatt und Sonnengras verändern, um den vorgegebenen Zielbereich bei Rotschwärmern und Blauschwärmer in höchstens 4 Schritten zu erreichen?
Issues in item development

Butterfly

Wildranke
Blassblatt
Sonnengras

Rotschwärmer
Blauschwärmer

Hilfe
Alles lösen
Ausführen!
Beende Aufgabe

Modell

Wildranke
Blassblatt
Sonnengras

Rotschwärmer
Blauschwärmer
C) MicroDYN & MicroFIN IV

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C) MicroDYN & MicroFIN VI

- Theoretical construct well embedded in software
- Any (1) number of items with (2) any chosen graphical cover possible
- Variety of (1) functional and (2) layout options
- Good experiences with the authoring system
- Close cooperation between IT-staff & item developers inevitable
Dynamic Problem Solving
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C) MicroDYN & MicroFIN VII
Wish Wash Wheel
Remote Control
D) Scaling and validity I

- Very good fit of the 3-dimensional model
  - $\text{Chi}^2 = 40.47$, $df = 28$, $p = .06$; $\text{CFI} = .98$, $\text{TLI} = .98$; $\text{RMSEA} = .06$ ($n = 238$)

- High correlations between dimensions, but reliably different from 1

Greiff, Wüstenberg & Funke (submitted)
D) Scaling and validity II

Chi^2=44.04, df=37, 
\( p=.19, \text{CFI}=.98, \text{TLI}=.99, \text{RMSEA}=.04 \) 
(n=238)
E) Extensions of DPS in CBA I

• Due to the high flexibility of the item builder, DPS can be extended to other constructs easily

• Examples:
  – From MicroDYN to MicroFIN
  – Common framework: MicroDYN & MicroFIN
  – From individual to collaborative DPS
F) Possibilities & challenges I

- Constructs derived from Cognitive Psychology
  - facets theoretically derived & empirically tested
  - Intradimensional competence levels (experimentally derived)
  - Experimental background
- Requires dynamic interaction & evaluates overt behavior
- Overarching frame of reference (item commensurability)
- Ease of change (in Itembuilder & Execution Environment)
F) Possibilities & challenges II

- Potential of measuring new constructs due to computer-based assessment
- DPS one of these constructs
- Potential to assess overt behavior and to capture processes
- Technical and practical difficulties are to be overcome
  - Online testing?
  - Hardware requirements

- New opportunities should not be wasted!
F) Possibilities & challenges III

• DPS as cross-curricular competence

• Impact / importance of CBA for assessment
• Ecological validity of CBA

• Relationship between
  – Software & Theory
  – Software developers & Test developers
  – Traditional & CBA-oriented constructs
Contact

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References


Thank you for your attention