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# Interactive Problem Solving within PISA 2012

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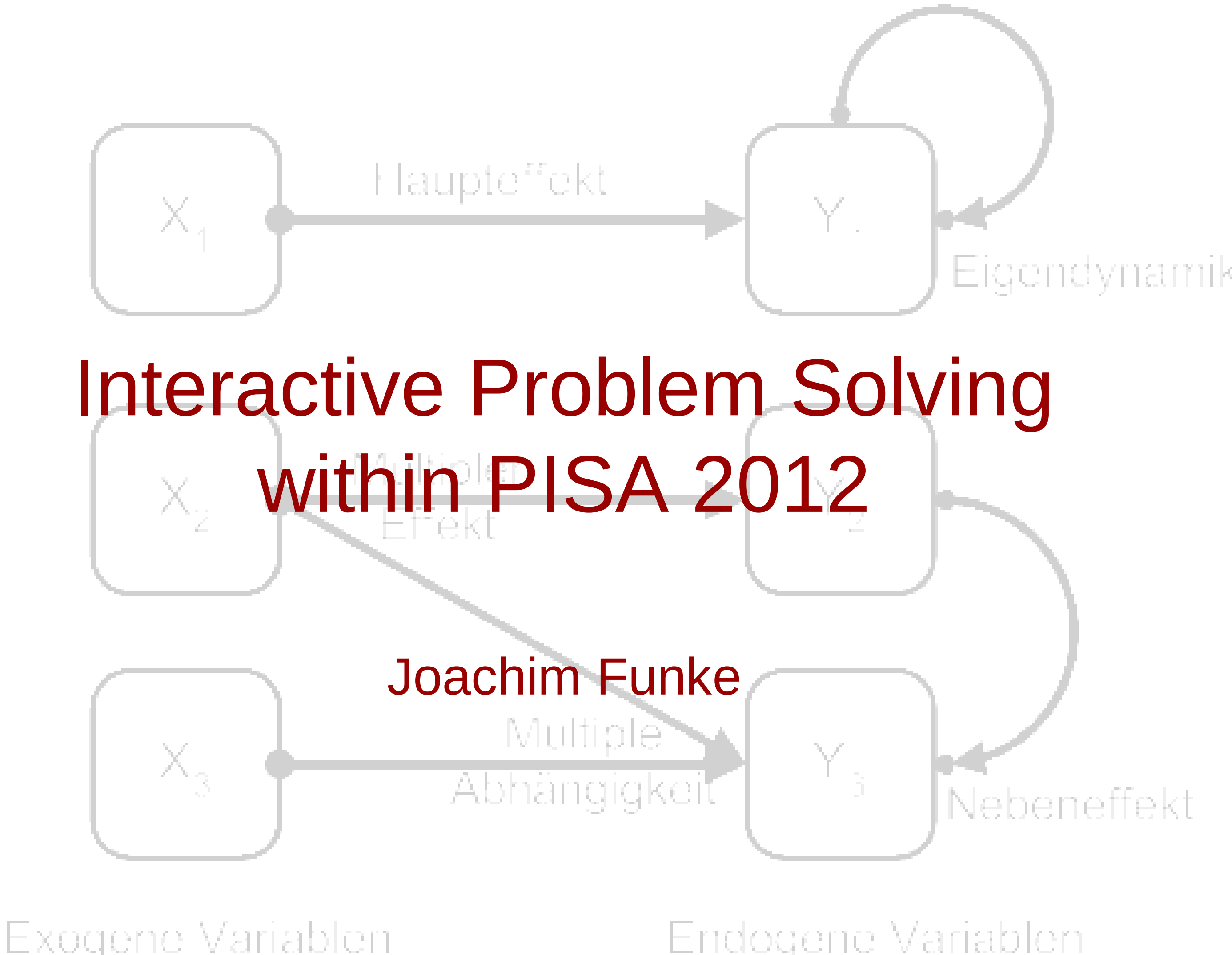


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# Problem solving in the 21st century

- dealing with complexity
  - reduction of complexity requires model building
- handling intransparency
  - producing transparency requires information retrieval
- understanding dynamics
  - control of systems requires forecasting
- balancing goal conflicts
  - solving conflicts requires prioritizing and compromising

# Examples in the real world

- technical systems
  - e.g., home appliances, vending machines
- social systems
  - e.g., social interactions in different contexts
- natural systems
  - e.g., environment, biology, medical science

- key point:
  - problem solving is a goal-directed interaction of a person with a system to overcome barriers
  - therefore in PISA 2012 focus on *interactive* problem solving
  - computer-based assessment allows for registration of the interaction process

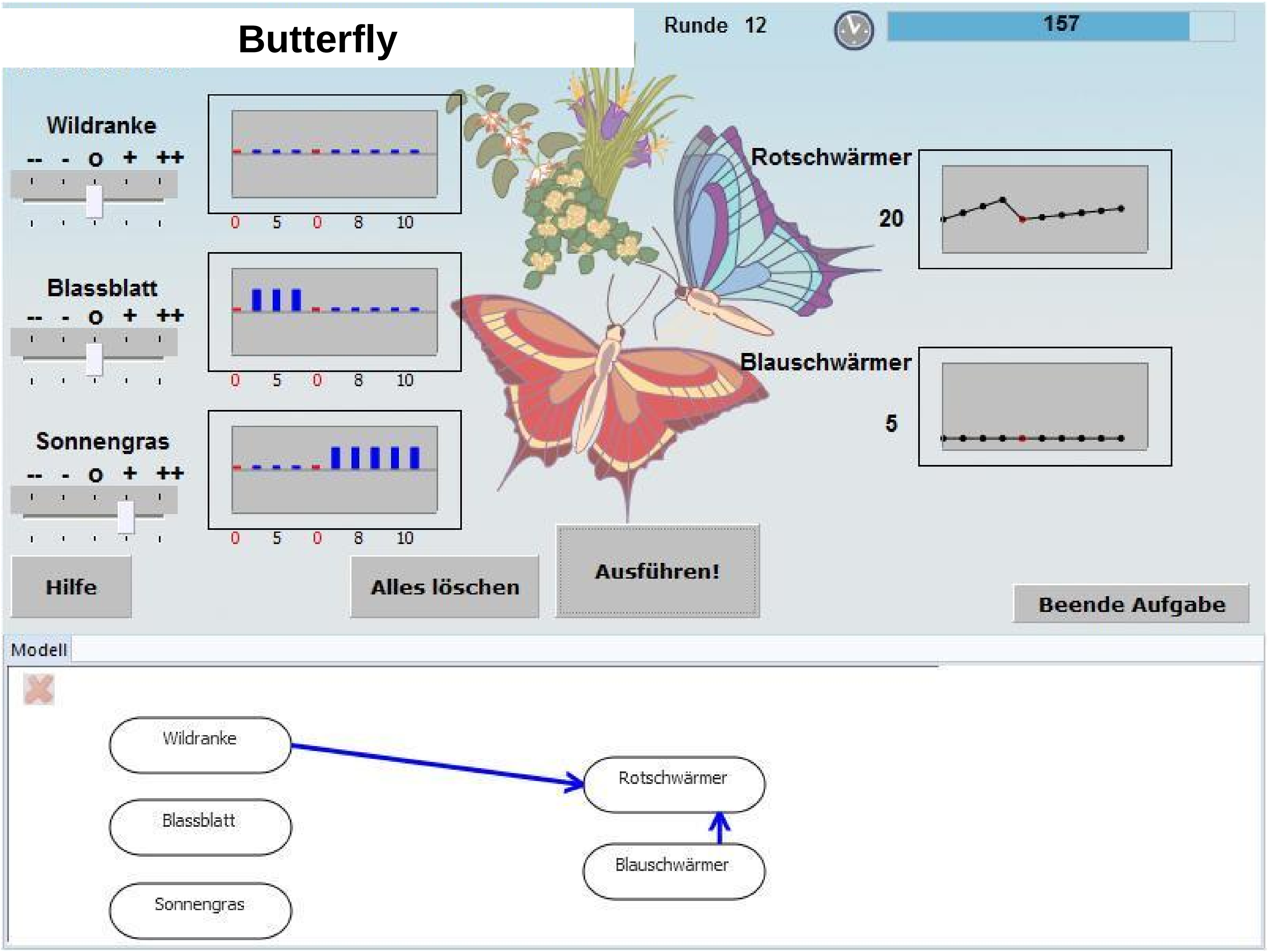
# New idea: “Minimal Complex Systems”

- classic assessment approach
  - to realize complex, dynamic environments for interactions with problem solvers, some researchers have proposed to use highly complex scenarios and and simulations
- new assessment approach
  - search for *minimal complex systems* which can be used for an assessment of participants’ interactions
    - allows short testing time (5 min per item)
    - allows construction of multiple independent items
    - allows assessment of sub-dimensions
- use of two formalisms for item construction
  - systems with continuous variables: linear structural equation systems (MicroDYN)
  - systems with discrete variables: finite state automata (MicroFIN)

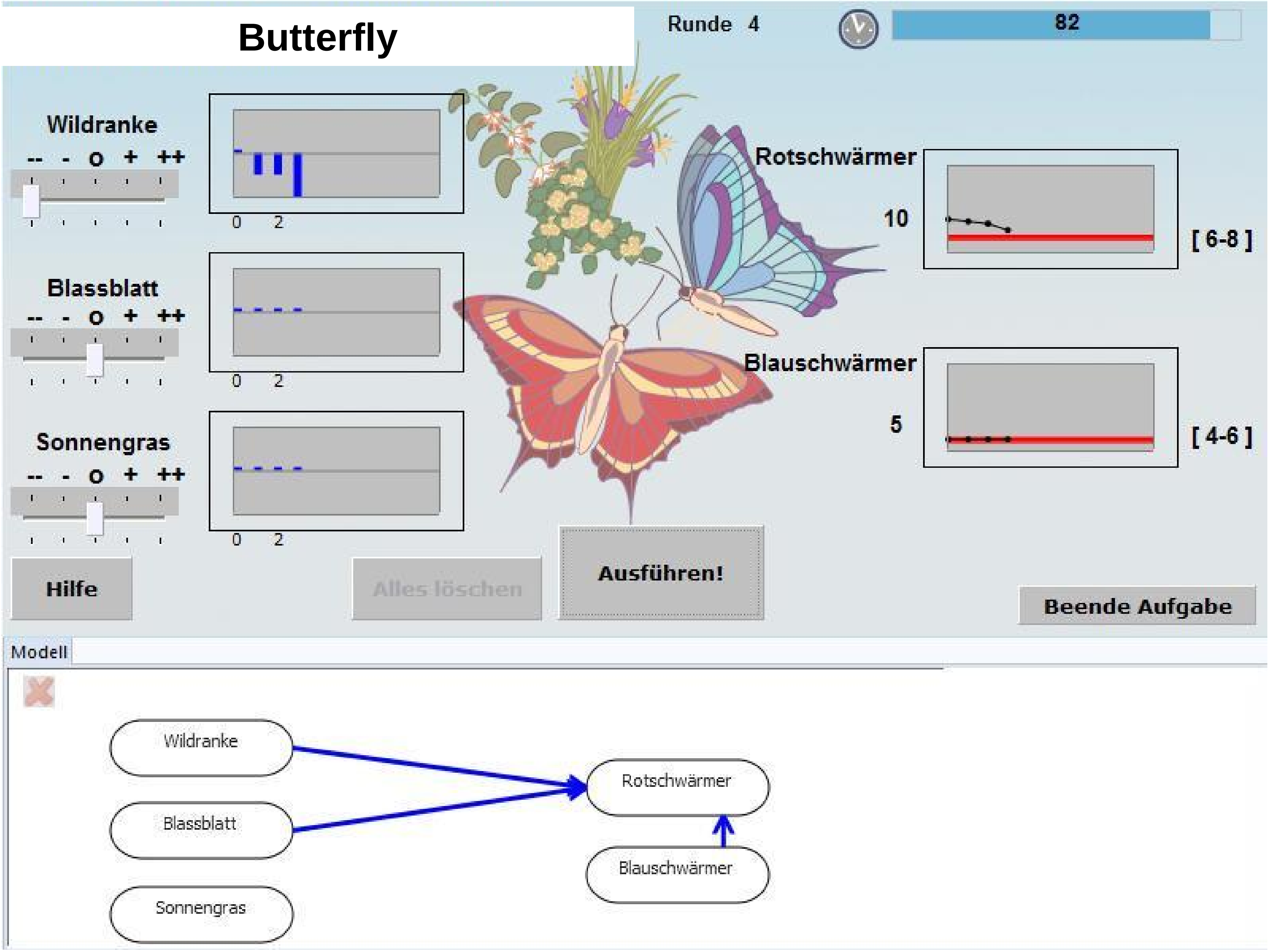
# The MicroDYN approach

- (A) Information retrieval:
  - „Explore the system.“
  - 180 seconds
  - PISA-framework: Exploring & Understanding
- (B) Model building
  - „Draw the connections between variables as you suppose.“
  - simultaneously to (A)
  - PISA-framework: Representing & Formulating
- (C) Forecasting
  - „Reach given target values on the endogenous variables by entering correct values in the system.“
  - 90 seconds
  - PISA-framework: Planning & Executing

*Several independent items are presented*

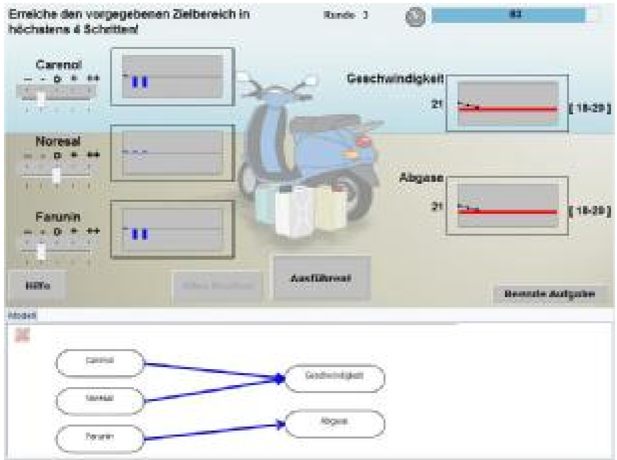


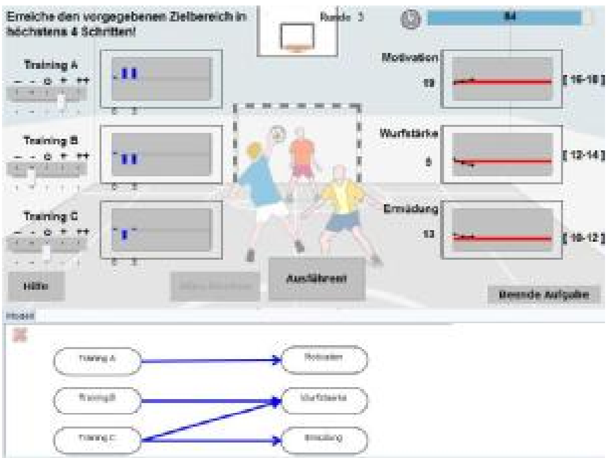
Butterfly
Runde 12
157
Wildranke
-- - o + ++
0 5 0 8 10
Blassblatt
-- - o + ++
0 5 0 8 10
Sonnengras
-- - o + ++
0 5 0 8 10
Rotschwärmer
20
Blauschwärmer
5
Hilfe
Alles löschen
Ausführen!
Beende Aufgabe
Modell
Wildranke
Blassblatt
Sonnengras
Rotschwärmer
Blauschwärmer

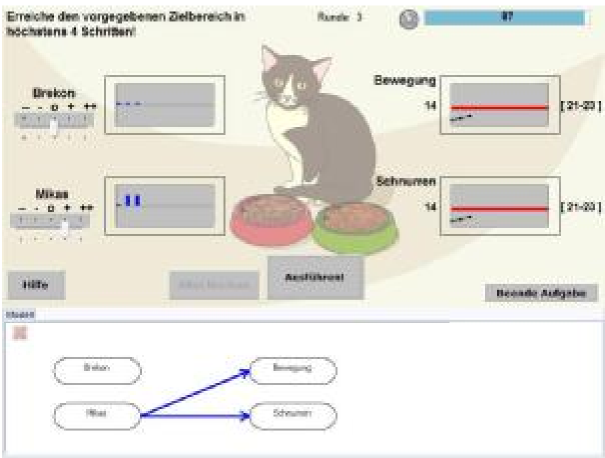

Butterfly
Runde 4
82
Wildranke
-- - o + ++
0 2
Blassblatt
-- - o + ++
0 2
Sonnengras
-- - o + ++
0 2
Rotschwärmer
10
[ 6-8 ]
Blauschwärmer
5
[ 4-6 ]
Hilfe
Alles löschen
Ausführen!
Beende Aufgabe
Modell
Wildranke
Blassblatt
Sonnengras
Rotschwärmer
Blauschwärmer

# MicroDYN Examples

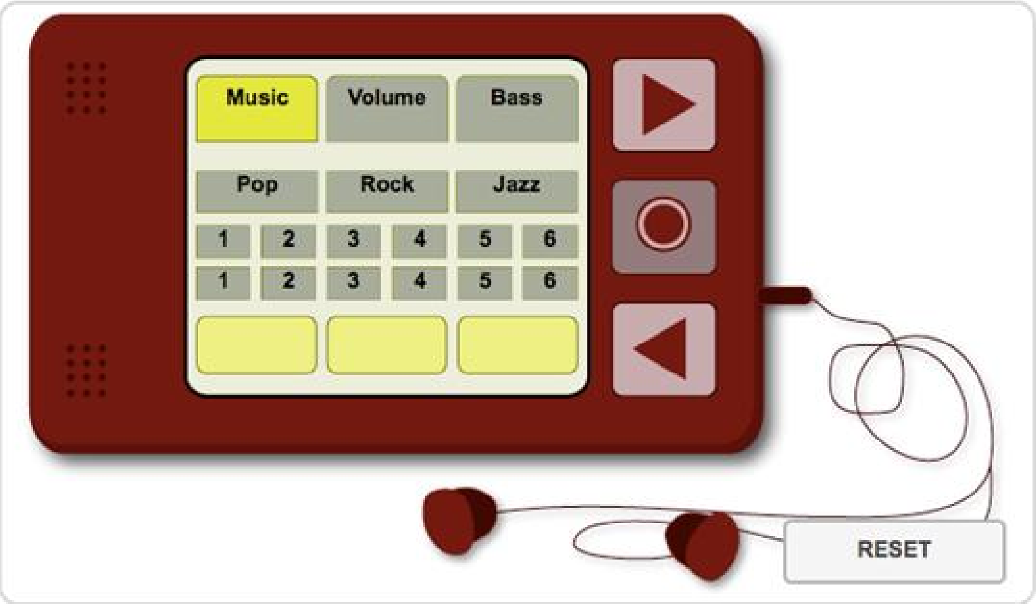
- Several authentic items developed, e.g. items with the semantics
  - “refueling a moped”, ”playing in a handball team”, “mixing a perfume”, “feeding cats”, “mixing elements in a chemistry lab” etc.



# MicroFIN: Examples




# How to score MicroDYN

- Information Retrieval
  - Full Credit: Use of VOTAT strategy (“**v**ary **o**ne **t**hing **a**t a **t**ime”) and use of zero rounds (=no intervention)
  - Partial Credit: Use of VOTAT, no use of zero rounds
  - No Credit: No use of VOTAT
- Model Building
  - Full Credit: Item log records that mental model is correct
  - Partial Credit: One error in the model
  - No Credit: More than one error in the model
- Forecasting
  - Full Credit: Target goals are reached
  - Partial Credit: Some progress towards target goals
  - No Credit: No progress towards target goals

**à** Also implemented in MicroFIN

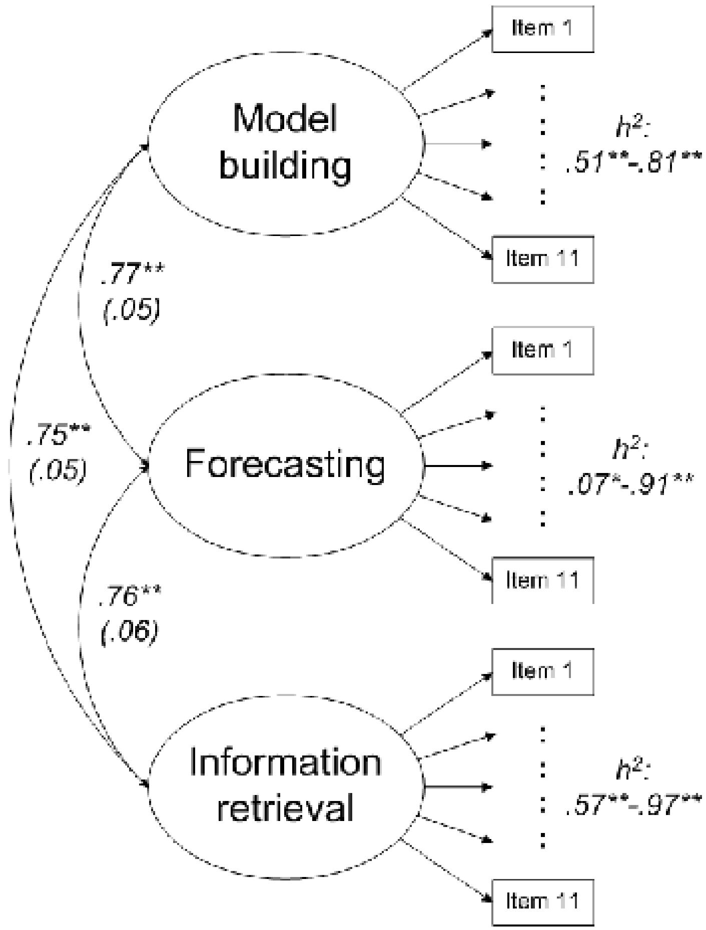
# Dimensions (Greiff, 2011)

§ 3-dimensional model with 3 facets as expected (n = 114; WLSMV-estimator).

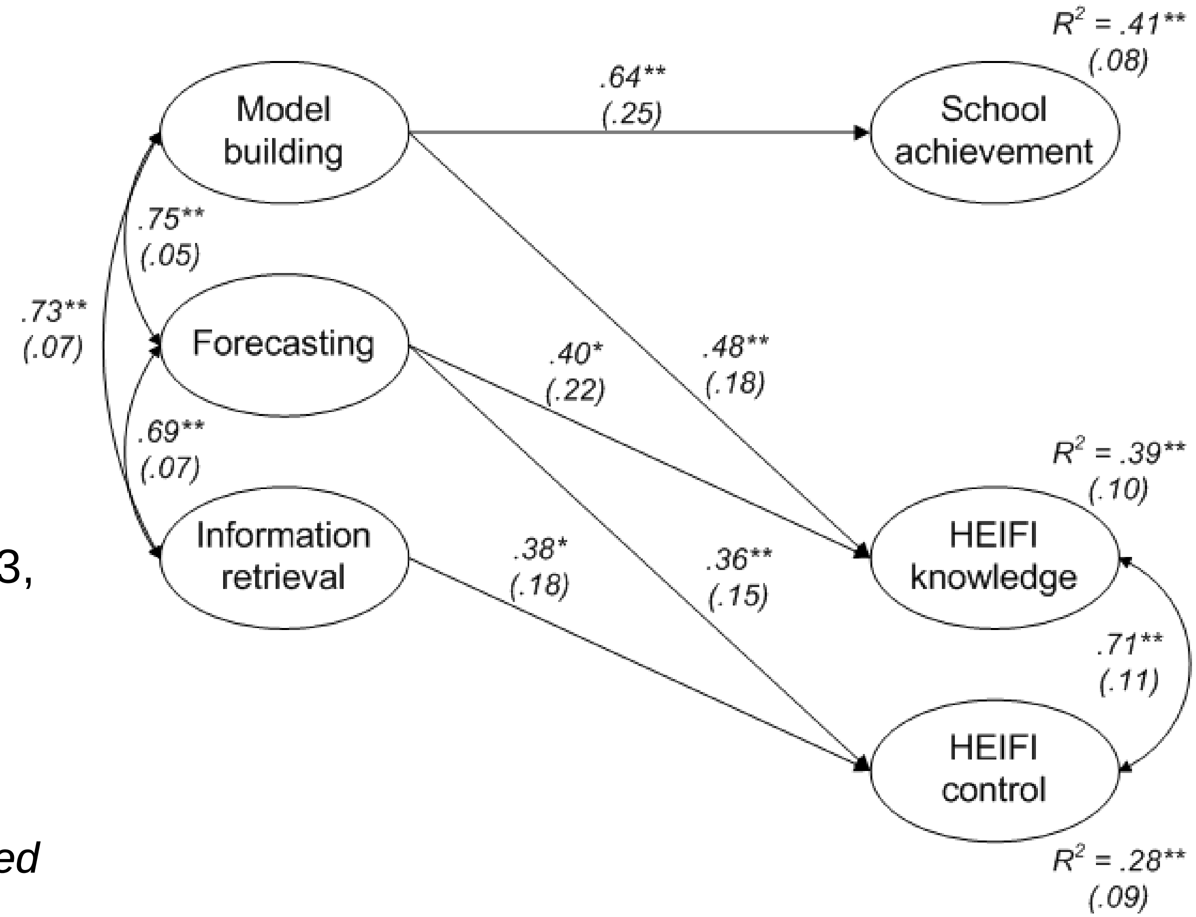
§ Correlations between dimensions justify separation of three facets.

§ Good communalities.

§ Model fit: $\chi^2 = 40.47$, df = 28, p = .06; CFI = .98; TLI = .98; RMSEA = .06



# Construct Validity (Greiff, 2011)




§ n = 114; WLSMV-estimator

§ Model fit: $\chi^2$ = 76.26, df = 53, p = .02; CFI = .97; TLI = .96; RMSEA = .07

*Only significant paths are depicted*

# Practical Issues

- Feasibility
  - CBA ItemBuilder and ExecutionEnvironment (produced by SoftCon, Munich, in cooperation with DIPF, Frankfurt)
  - allows computer-based construction, presentation, and assessment of MicroDYN and MicroFIN items
- Costs
  - Item Development (in a German university setting):
    - about 10.000 Euro (approx. 13.000 USD) per Unit
    - plus 5.000 Euro (approx. 6.500 USD) for CogLab
  - License for CBA ItemBuilder and ExecutionEnvironment:
    - DIPF, Frankfurt, will give it probably for free for scientific use

# Summary

- Understanding of Problem Solving:
  - Problem Solving as interaction with complex, dynamic environments
- Formal Frameworks:
  - use of formal frameworks for construction of highly variable scenarios (which remain comparable)
- Minimal Complex Systems:
  - bottom level of complexity allows for short testing time and use of multiple items from different domains
- Empirical evidence:
  - good quality of assessment up to now; more data to come with PISA Field Trial 2011 with dozens of MicroDYN and MicroFIN items (from ~70 countries with ~7000 subjects)

# Thank you!

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