UNIVERSITY OF TWENTE.

FUTURE DEVELOPMENTS IN EDUCATIONAL SCIENCE AND TECHNOLOGY ENHANCED LEARNING

TON DE JONG

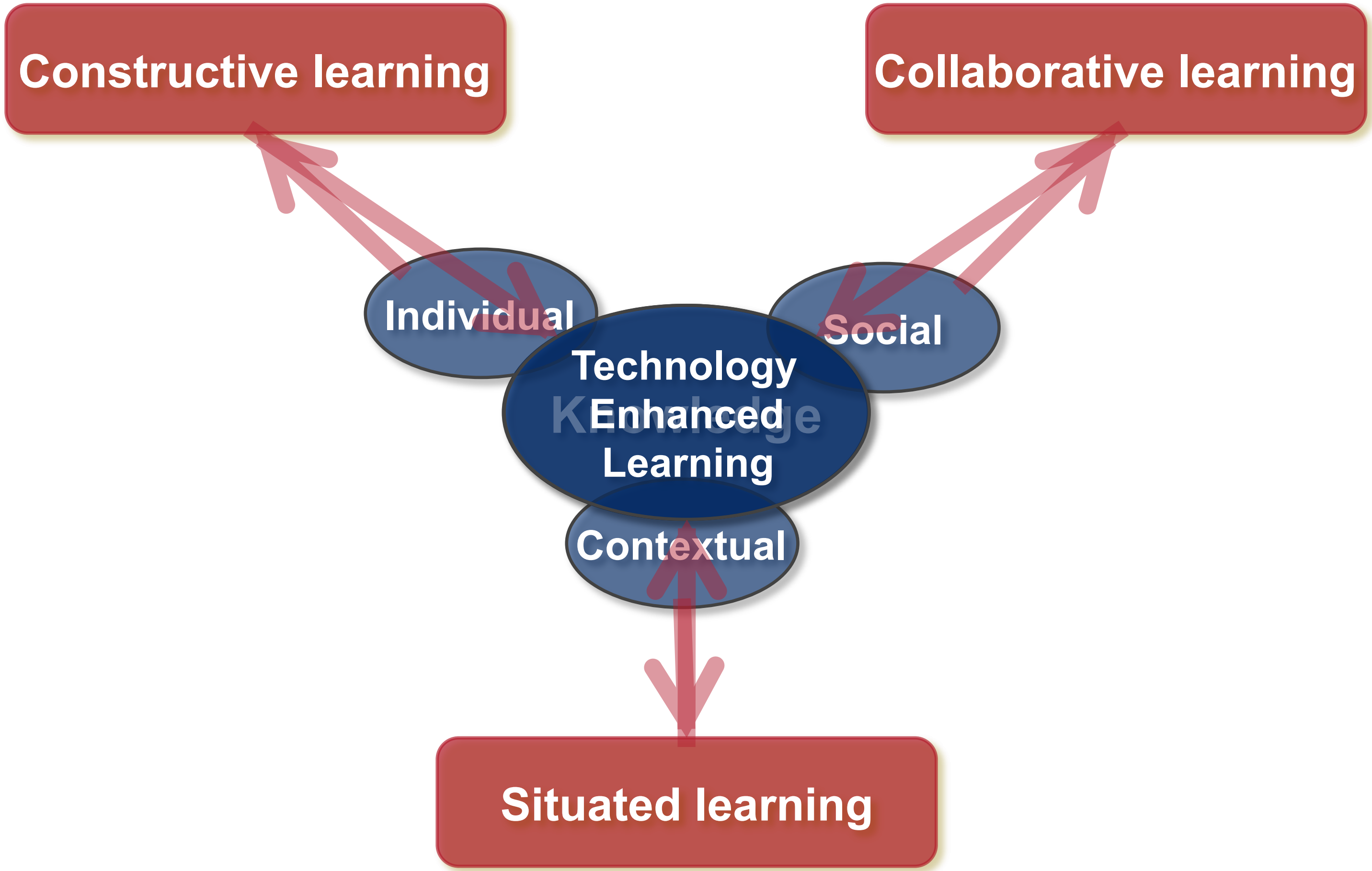
UNIVERSITY OF TWENTE

THE NETHERLANDS

OVERVIEW OF THE PRESENTATION

- Developments in education and related ICT developments
- Focus on (collaborative) learning_with simulations
- Cognitive aspects of inquiry learning
- How to create educationally well designed simulations?
- Open questions and future directions

DEVELOPMENTS IN EDUCATION

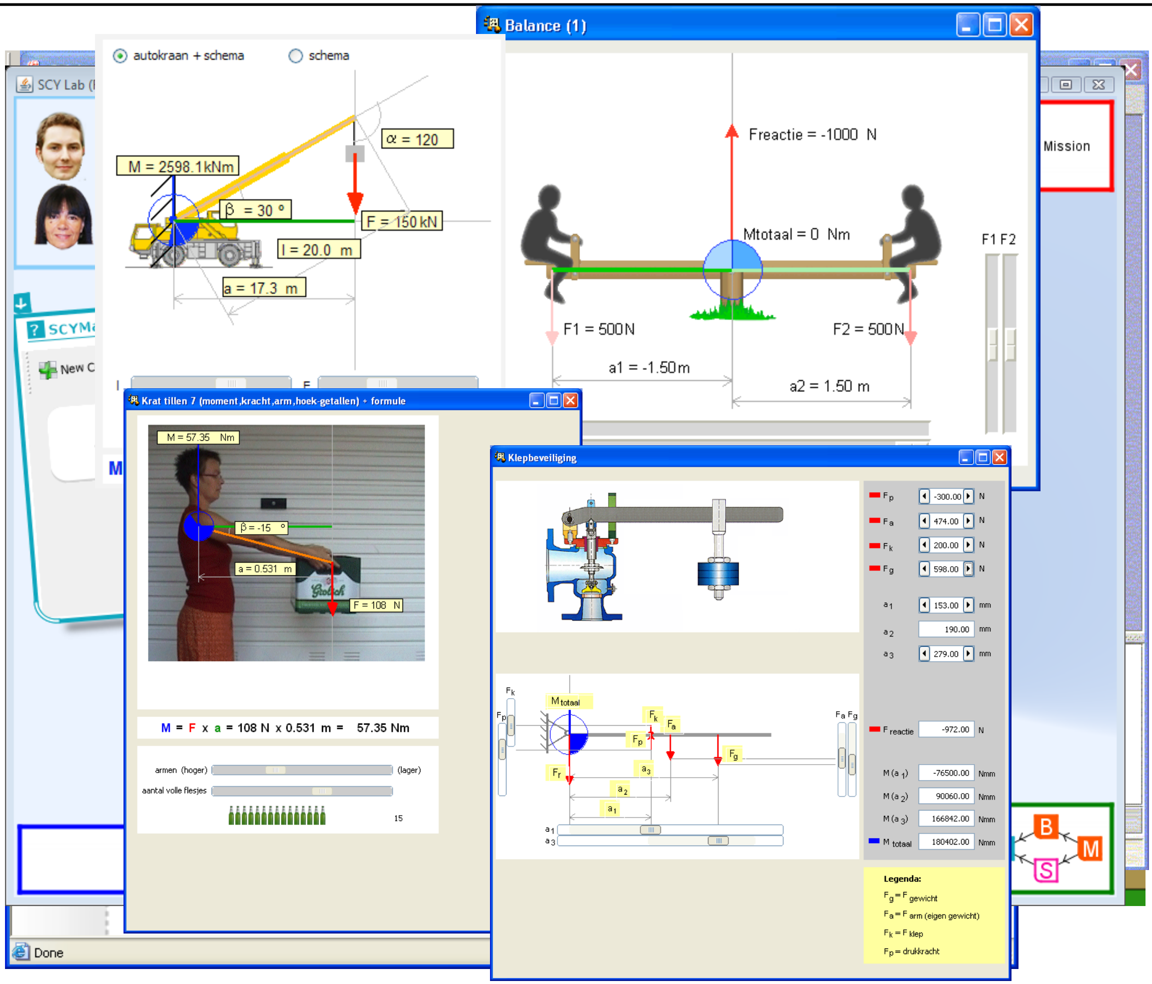


DEVELOPMENTS IN TECHNOLOGY ENHANCED LEARNING

- Constructive learning
  - Inquiry learning
  - Constructionism
  - Computer simulations/games
  - Modelling environments
- Collaborative learning
  - Shared representations
  - Chats
  - Scripts
- Situated learning
  - Realistic topics
  - Simulators (e.g., medicine)

EXAMPLES OF OUR WORK IN TWENTE

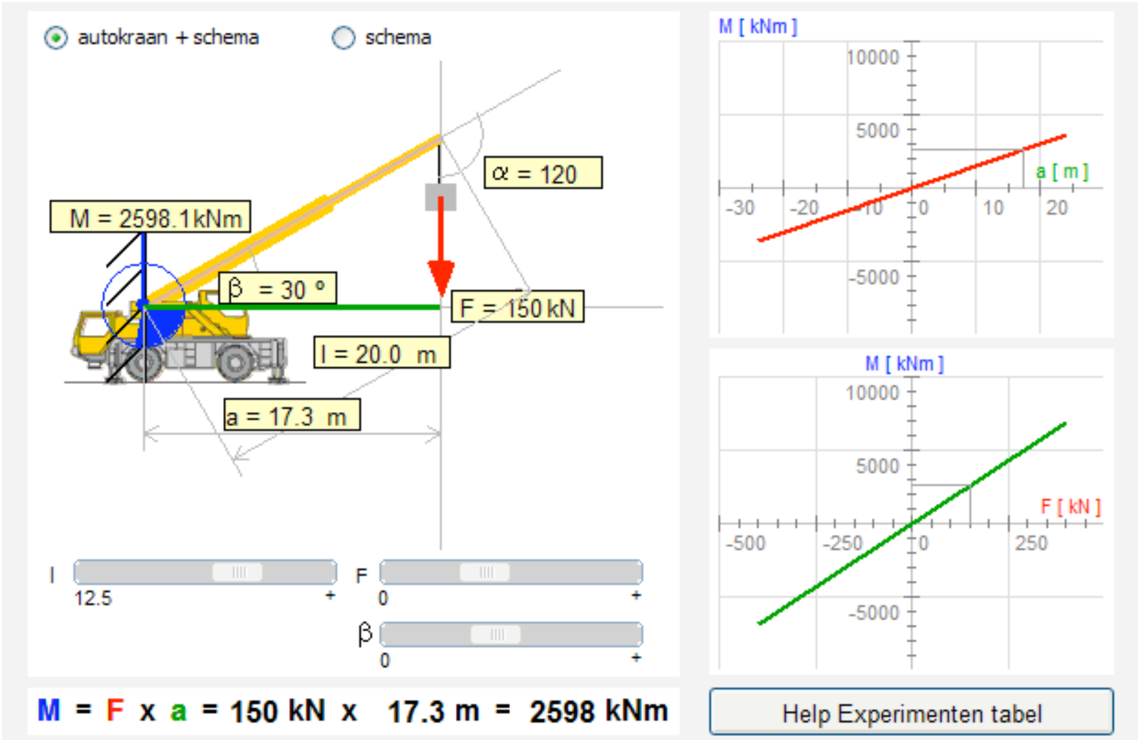
- SimQuest
- Co-Lab
- KMQuest
- ZAP
- SCY



WHY SHOULD LEARNING WITH SIMULATIONS WORK?

- Inquiry learning; following a scientific investigation cycle (e.g., de Jong 2006, many others)
- Multiple representations (Ainsworth, 2006)
- Interactive visualizations (Lindgren & Schwartz, 2009)
- *Should lead to better integrated, more insightful, and more intuitive knowledge*

AN EXAMPLE SIMULATION



Exp Nr	beta	a	alpha	F	l	M
–	30.0	17.3	120.0	150.0	20.0	2598.1

BUT IT DOESN'T WORK JUST LIKE THAT!

SCAFFOLDING IS NEEDED

- Orientation
- Hypothesis generation
- Experimentation
- Concluding
- Planning
- Monitoring
- Reflection

- Connecting representations
- Translating between representations

- Support to contrast cases

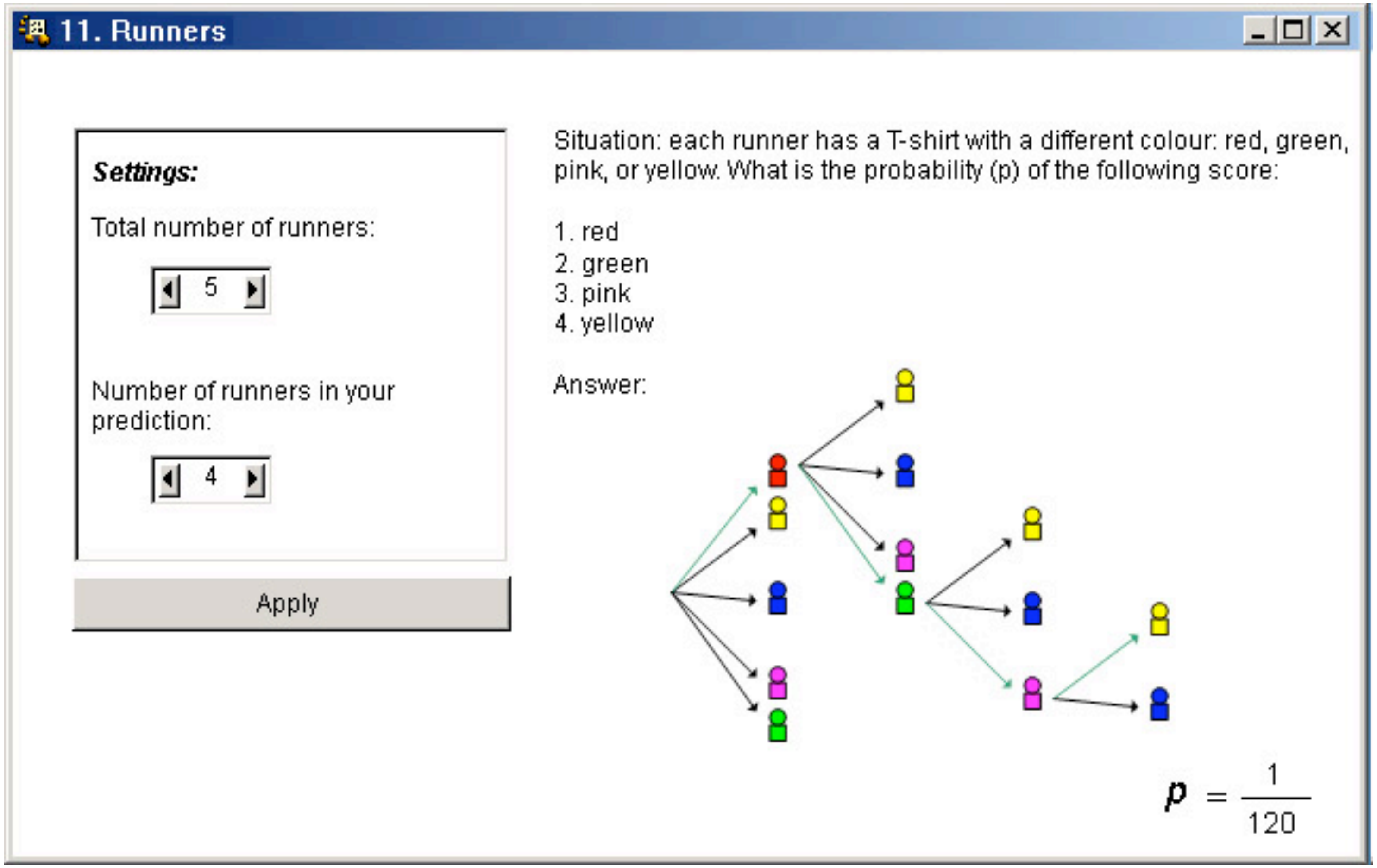
SIMULATION BASED LEARNING COMPARED TO TRADITIONAL, EXPOSITORY, INSTRUCTION

- If well designed, so scaffolds included, simulation show an advantage over expository instruction (large scale evaluations)
  - Shute & Glaser, 1990: *Smithtown*
  - White & Frederiksen,1998: *ThinkerTools*
  - Hickey, Kindfield, Horwitz, & Christie, 2003: *GenScope*
  - Linn, Lee, Tinker, Husic, & Chiu, 2006: *TELS*
  - de Jong, Hendrikse, & van der Meij, in press: *SimQuest Math*
- Effects on conceptual (intuitive) knowledge

SIMULATION BASED LEARNING COMPARED TO TRADITIONAL, LABORATORY, INSTRUCTION

- Students in simulation based environments score better than or at the same level as students in a real laboratory
  - Chang, Chen, Lin, & Sung, 2008
  - Klahr, Triona, & Williams, 2007
  - Van Klink, Wilhelm, & Lazonder, submitted
- Students learning in a sequence of simulation and real laboratory outperform the simulation and/or laboratory.
  - Zacharia & Anderson, 2003
  - Zacharia, 2007
  - Jaakkola & Nurmi, 2008
  - Zacharia, Olympiou, & Papaevripidou, 2008
- Effects on conceptual knowledge

THE EFFECTIVENESS OF INQUIRY LEARNING



A COMPARISON OF INSTRUCTIONAL STRATEGIES

- Performance (different types of knowledge):
  - EL > IL > (HL = OL)
  - For far transfer IL scores higher
- Efficiency:
  - HL > (IL = OL) > EL

Eysink, T.H.S., de Jong, T., Berthold, K., Kolloffel, B., Opfermann, M., & Wouters, P. (in press). Learner performance in multimedia learning arrangements: an analysis across instructional approaches. *American Educational Research Journal*

HOW TO DESIGN SUPPORTIVE INQUIRY ENVIRONMENTS?

PROBLEMS IN INQUIRY LEARNING

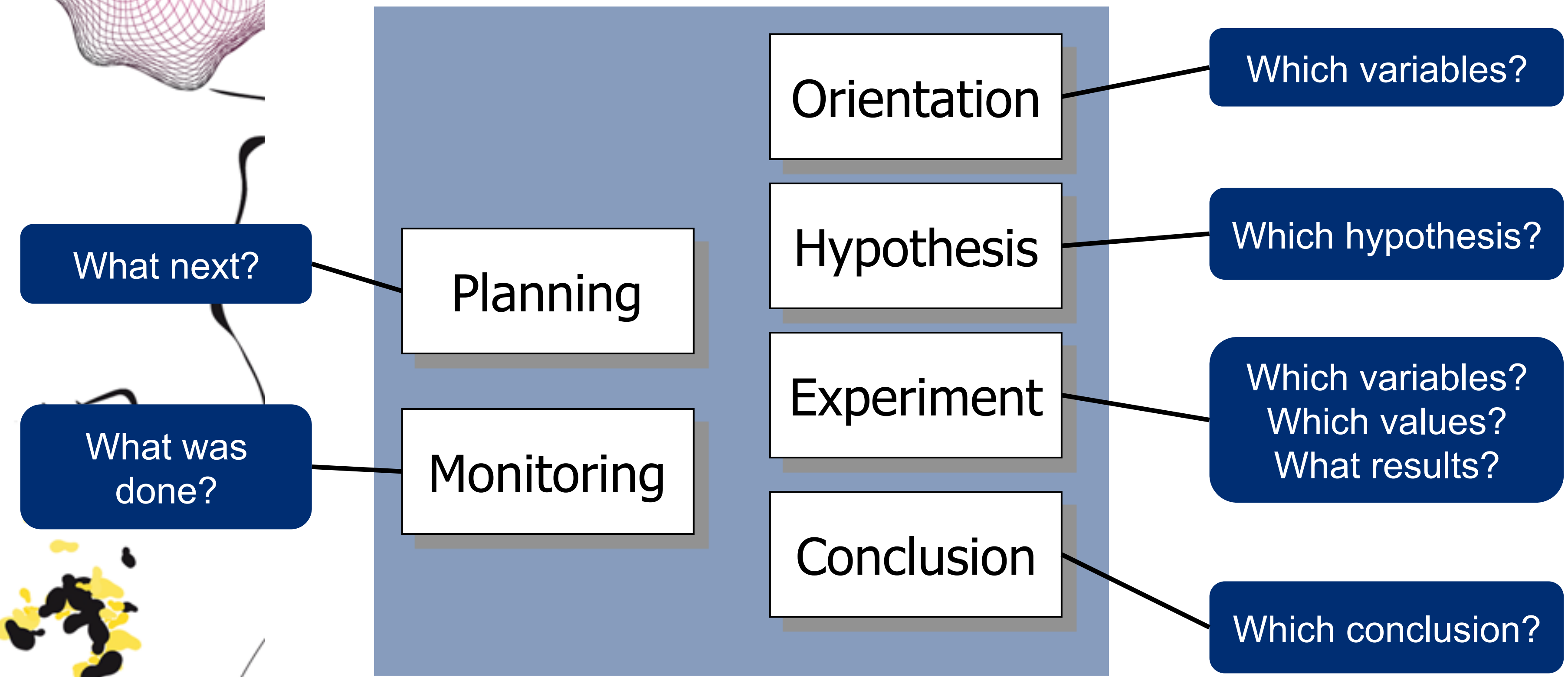
- Poor hypotheses
- Ineffective experiments
- Engineering approach
- Mistakes in data interpretation
- No planning and monitoring (floundering)
- etc.

SCAFFOLDS

- Assignments
- Explanations
- Model sequencing
- Monitoring facilities
- Hypothesis scratchpad
- Prompts
- Hints
- Data interpreters
- Etc. etc.

de Jong, T. (2006). Computer simulations - Technological advances in inquiry learning. *Science*, *312*, 532-533.

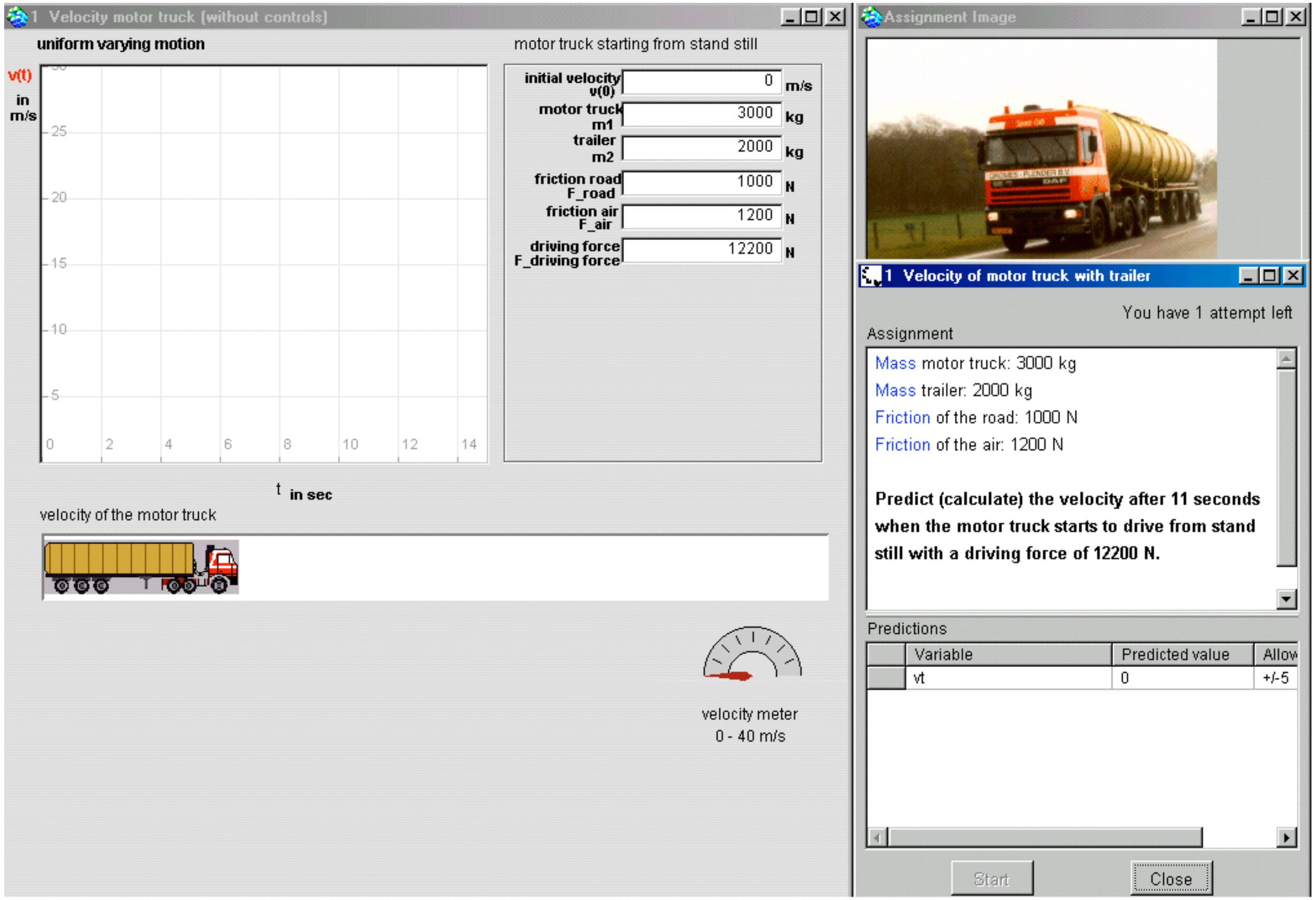
SCAFFOLDS AND COLLABORATIVE INQUIRY



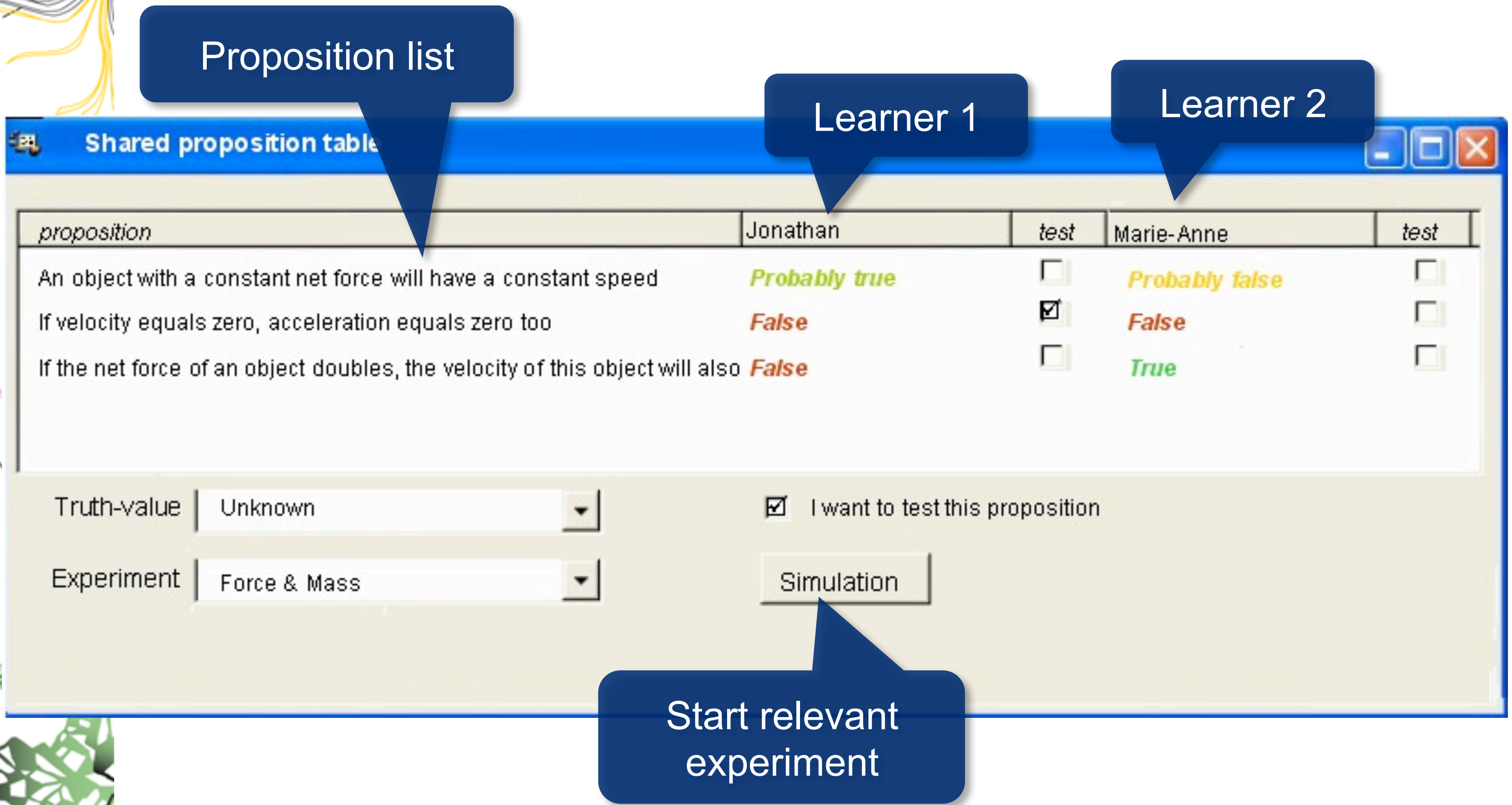
COLLABORATIVE INQUIRY

- Differences in opinion should lead to discussion and progress in learning
  - Okada and Simon (1997)
  - Gijlers, H., & de Jong, T. (2005). The relation between prior knowledge and students' collaborative discovery learning processes. *Journal of Research in Science Teaching, 42*, 264-282.
- Focus on hypothesis generation
  - Gijlers, H., & de Jong, T. (2009). Sharing and confronting propositions in collaborative inquiry learning. *Cognition and Instruction*, *27*, 239-268.

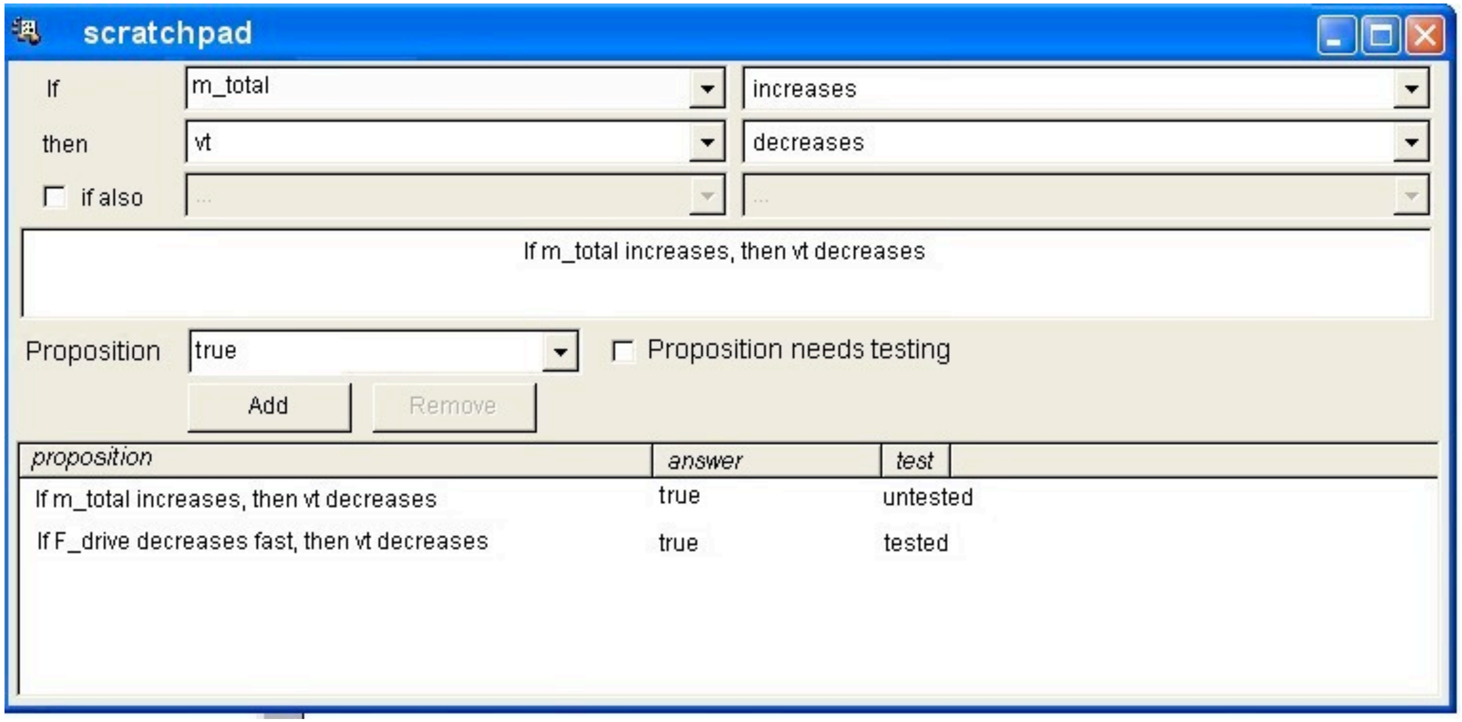
SUPPORTING COLLABORATIVE INQUIRY



SHARED PROPOSITION LIST



PROPOSITION SCRATCHPAD



RESULTS (IN A NUTSHELL)

- Shared proposition table condition:
  - *significantly higher learning gains than shared hypothesis scratchpad and control*
- Shared proposition table condition:
  - *discussed significantly more unique propositions (on which they disagreed)*
  - *explored a larger proportion of the simulated domain*
  - *A positive correlation between number of unique propositions and test scores was found*

HOW TO COME FROM COGNITION TO TEL SYSTEMS?

INQUIRY PROCESSES,

- Basic research
  - Experimental studies (smaller (n = approx 25 per condition) or larger number (n = 100+ per condition) of students)
  - Small scale, qualitative, studies
  - In realistic situations

- Usability studies
  - (Larger scale) applications

TECHNIQUES USED

- Experimental manipulations: pre-test post-test control group design
- Knowledge tests, questionnaires
- Process analysis
  - Thinking aloud protocols
  - Log-file analysis
  - Chat analysis
  - Neuropsychological techniques

EXAMPLE OF A STUDY WITH NEURO-TECHNIQUES

- Question: How do students process different representations?

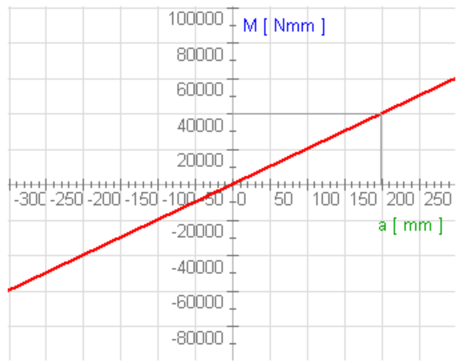
- 18 subjects, within subject design
- Four representations: Concrete, Formula, Table, Graph
- No task and task conditions (identify values)

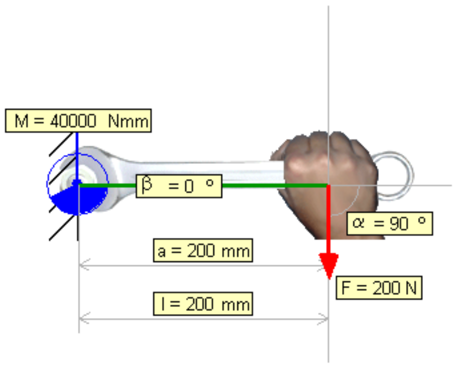
- EEG: Event related potentials

- Van Leeuwen, Th., van der Meij, J. & de Jong, T. (submitted). Event-related potentials as a window on external representations

REPRESENTATIONS USED

M = F x a = 200 N x 200 mm = 40000 Nmm





F	alpha	beta	l	a	M
- 350	90	0	200	200	-70000
- 300	90	0	200	200	-60000
- 250	90	0	200	200	-50000
- 200	90	0	200	200	-40000
- 150	90	0	200	200	-30000
- 100	90	0	200	200	-20000
- 50	90	0	200	200	-10000
0	90	0	200	200	0
50	90	0	200	200	10000
100	90	0	200	200	20000
150	90	0	200	200	30000
200	90	0	200	200	40000
250	90	0	200	200	50000
300	90	0	200	200	60000
350	90	0	200	200	70000

RESULTS

- Behavioral data
  - Accuracy: picture > formula, graph, table
  - Reaction time: formula < graph, picture < table
- ERP
  - No task condition
    - P1 (sensory analysis): picture > formula
    - P3 (cognitive processing): picture > formula
  - Task condition
    - P3 (cognitive processing): graph > formula

BUT THERE IS MORE

- *General considerations*
  - Interactive
  - Fast – Immediate - Always
  - Dynamic
  - Multi-faceted (not boring)
  - Socially entrenched
- *Practical considerations*
  - The length of a lesson
  - Examination requirements
  - Technical constraints
  - The skills of the teacher
  - Etc. etc.

RESEARCH AGENDA

- The role of “products” to design
  - Models (qualitative and quantitative)
  - Concept maps
  - Assignments
- The role of representations
  - Affordances of different types of representations (textual, arithmetical, graphical)
  - Multiple representations
- Collaboration and inquiry
  - Interaction between task related activities and communicative activities
- Process analysis/Adaptive environments/Individual differences
  - Interaction data
  - Neuropsychological data
  - Assessment of models
  - Educational data mining

CONCLUSIONS

- TEL is a combination of
  - Cognition
  - Technology
  - Educational science
- Doing “in vivo” research has many challenges

- **But we are the edge of exiting developments!**