

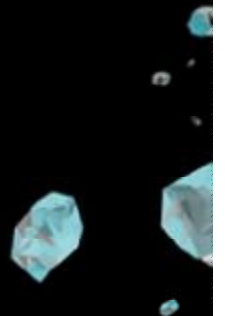
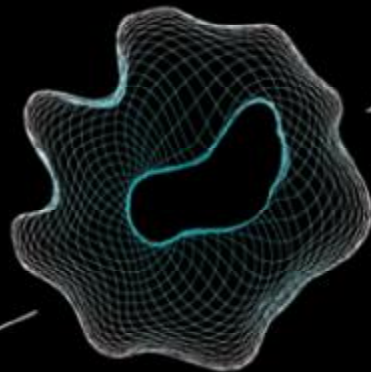
UNIVERSITY OF TWENTE.

LEARNING WITH COMPUTER SIMULATIONS EVIDENCE AND FUTURE DIRECTIONS

TON DE JONG

UNIVERSITY OF TWENTE

THE NETHERLANDS



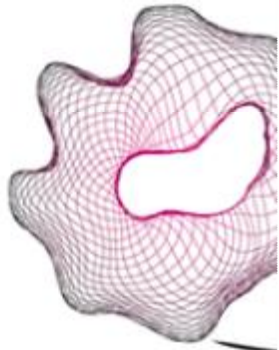


WHAT ARE SIMULATIONS?

§ “...simulations as computational models of real or hypothesized situations or phenomena that allow users to explore the implications of manipulating parameters within the models, ~~and/or modify or extend the model.~~” Clark et al.

§ de Jong, T. (in preparation). Learning with simulations. In R. E. Mayer & P. A. Alexander (Eds.). *Handbook of Research on Learning and Instruction*. Routledge Press.

EXAMPLES OF OUR WORK IN TWENTE



§ SimQuest

§ Co-Lab

§ KMQuest

§ ZAP

§ SCY

The collage displays several physics simulation software windows:

- autokreen - scheme:** Shows a crane arm with a force $F = 1000 \text{ N}$ at an angle of 30° . The moment is $M = -2598.14 \text{ Nm}$. Other parameters include $x = -17.3 \text{ m}$, $y = 10 \text{ m}$, and $F = 1400 \text{ N}$.
- Balance (1):** Shows a seesaw with a pivot. A reaction force $F_{\text{reactie}} = 1000 \text{ N}$ acts upwards at the pivot. Distances from the pivot are $x_1 = -1.5 \text{ m}$ and $x_2 = 1.5 \text{ m}$.
- Kinetik 2 (person):** Shows a person holding a weight. The weight is $F = 108 \text{ N}$ at a distance $a = 0.531 \text{ m}$. The resulting moment is $M = F \cdot x \cdot a = 108 \text{ N} \times 0.531 \text{ m} = 57.36 \text{ Nm}$.
- Kinetik 2 (mechanical):** Shows a complex mechanical system with multiple forces F_1 through F_5 and moments M_1 through M_5 . A free-body diagram is shown below the main image.

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WHY SHOULD LEARNING WITH SIMULATIONS WORK?

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



BUT THEY DON'T WORK JUST LIKE THAT!

SCAFFOLDING IS NEEDED

- § Orientation
- § Hypothesis generation
- § Experimentation
- § Data interpretation
- § 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

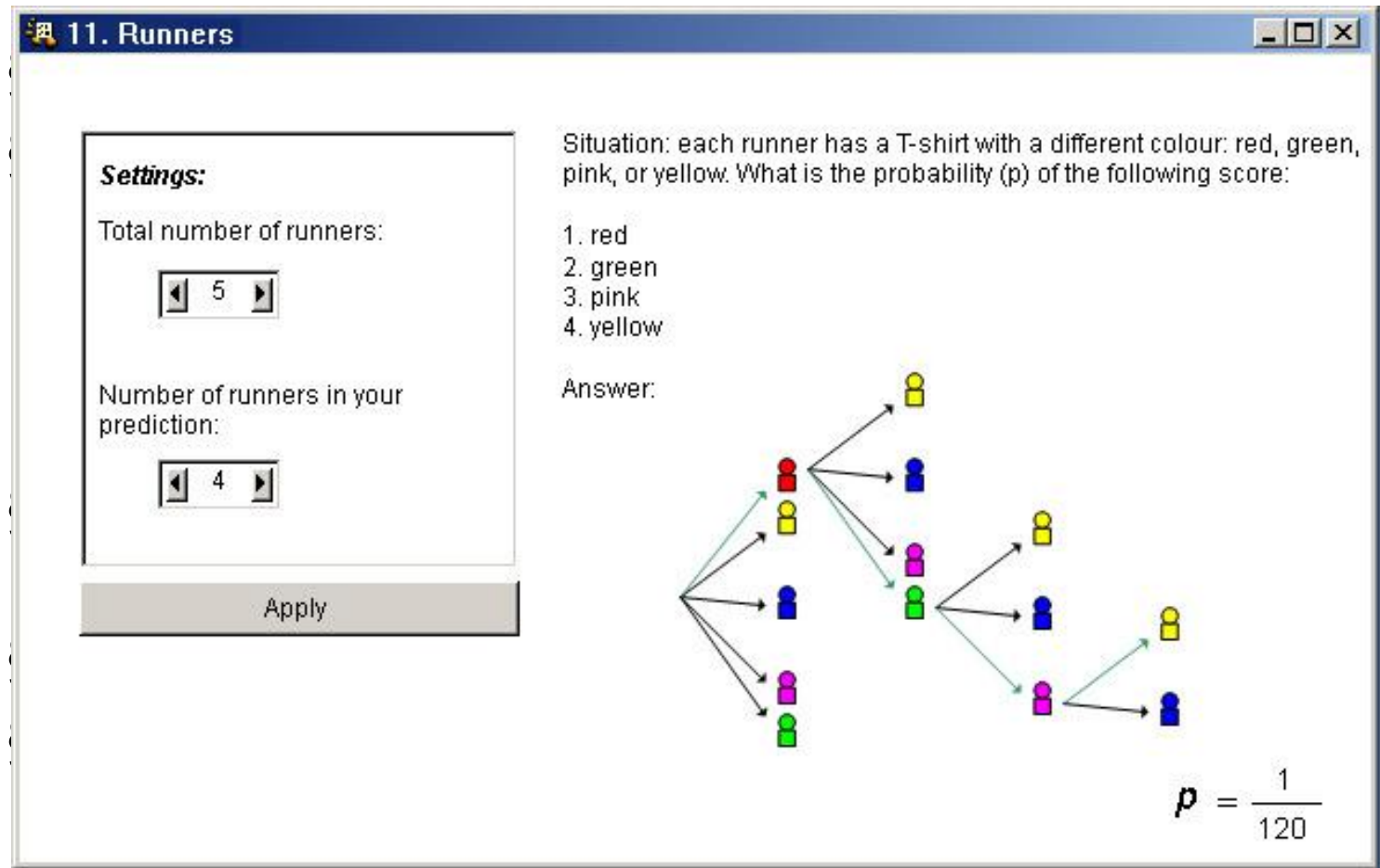
§ Zacharia, 2007

§ Jaakkola & Nurmi, 2008

§ Zacharia, Olympiou, & Papaevripidou, 2008

§ Effects on conceptual knowledge

THE EFFECTIVENESS OF INQUIRY LEARNING



11. Runners

Settings:

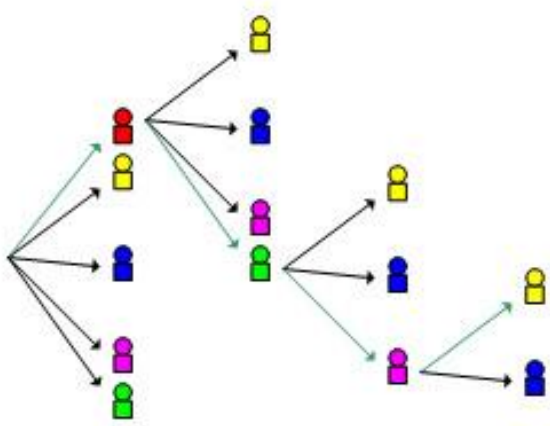
Total number of runners:

Number of runners in your prediction:

Situation: each runner has a T-shirt with a different colour: red, green, pink, or yellow. What is the probability (p) of the following score:

1. red
2. green
3. pink
4. yellow

Answer:



$p = \frac{1}{120}$



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*



CONCLUSION AND (A LITTLE) FUTURE

- § Simulation based learning has potential compared to direct instruction, laboratory exercises and other didactical approaches
- § Unguided inquiry is not fruitful; scaffolding (either computer-based or teacher provided) is needed
- § There is a focus on conceptual knowledge. More research on other types of content knowledge (e.g., procedural), inquiry skills, Nature of Science (NoS), and attitudes towards science is needed
- § Research on adaptive scaffolding is needed (and therefore on-line diagnosis should be improved (e.g., with data mining technologies))
- § Little is known on individual differences and the influence of specific abilities on learning with simulations