# Visual Learning and Communication

## Educational Perspectives

**Konrad J. Schönborn**

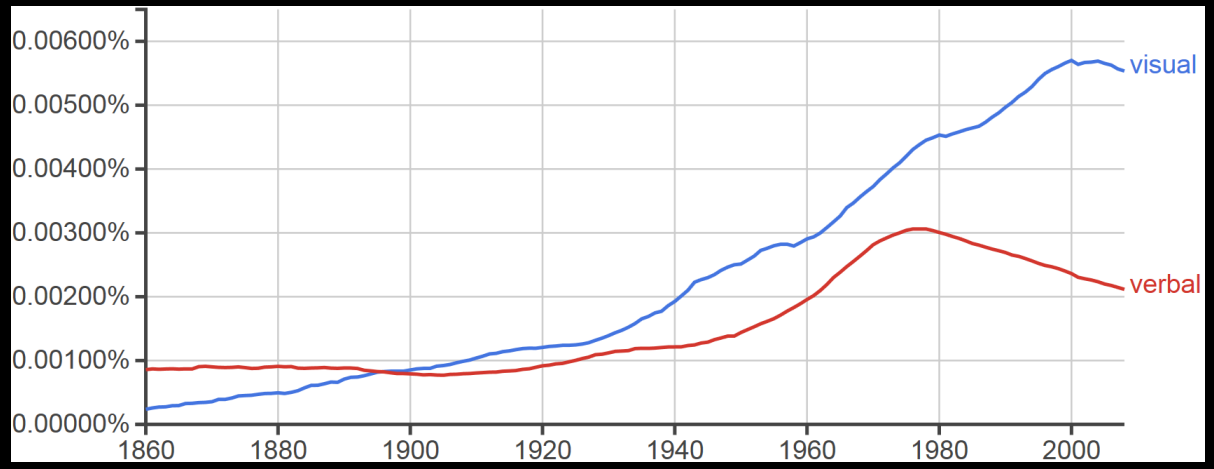
20 August 2021

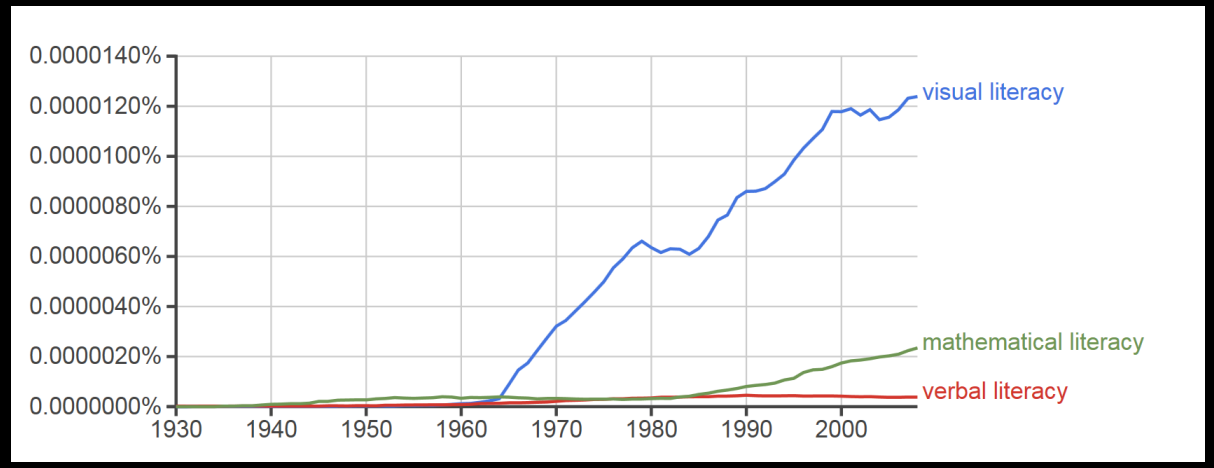
LINKÖPING UNIVERSITY

# Session Objective

- Visual Learning
- Visual Communication
- Investigation

# Trends in the Corpora




COGNITIVE SCIENCE **11**, 65–99 (1987)

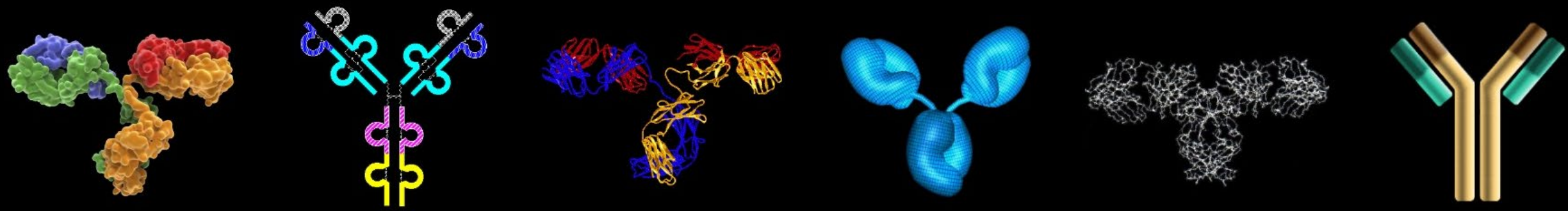
## Why a Diagram is (Sometimes) Worth Ten Thousand Words

JILL H. LARKIN
HERBERT A. SIMON
*Carnegie-Mellon University*

## The Cambridge Handbook of Multimedia Learning

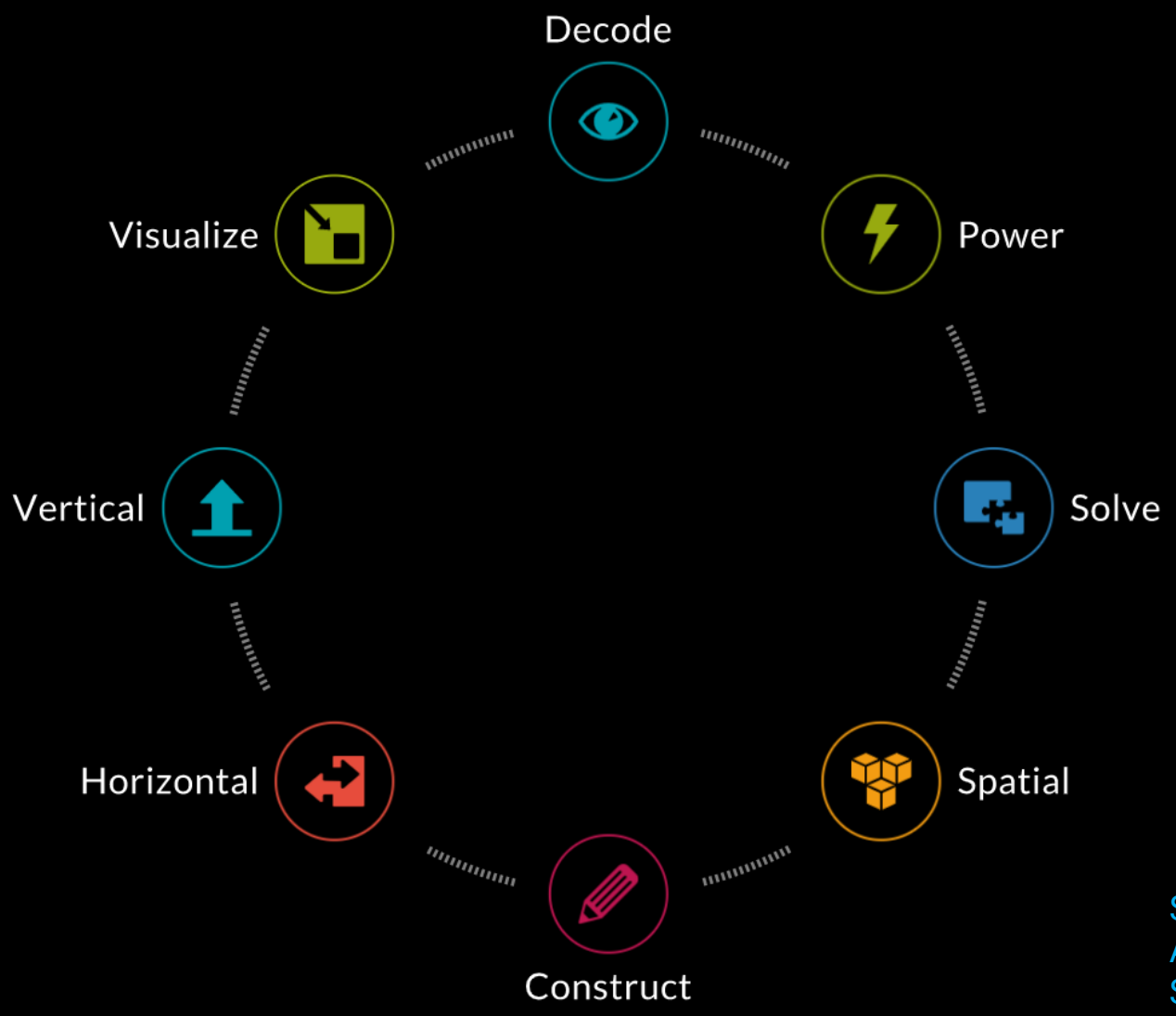
*Edited by*
Richard E. Mayer
*University of California, Santa Barbara*

# Visualization in Science Education: New Challenges



Schönborn (2005); Schönborn & Anderson (2010, 2009, 2006)

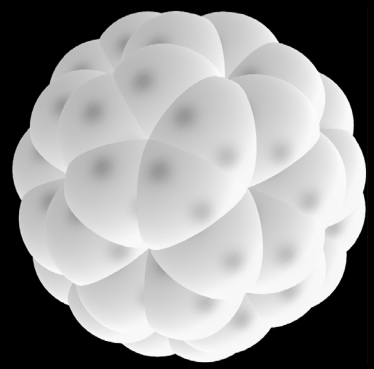
# Visualization in Science Education: New Directions



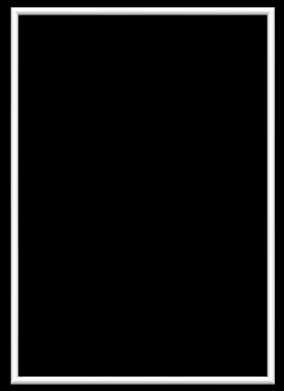

Schönborn (2005); Schönborn & Anderson (2010, 2009, 2006); Schönborn & Bögeholz, (2009)

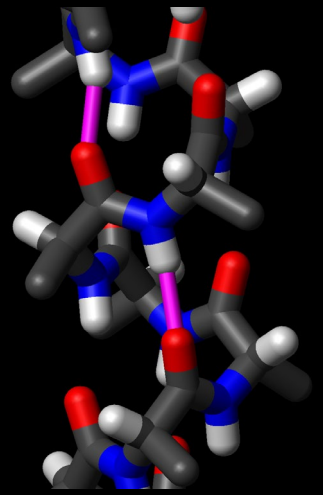
# How do Visual Representations Work?

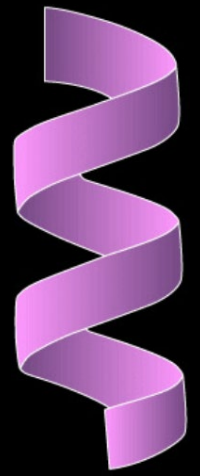
- Computational offloading
- Re-representation
- Graphical constraining



***"A plane figure with four straight sides and four right angles, with unequal adjacent sides, in contrast to a square"***







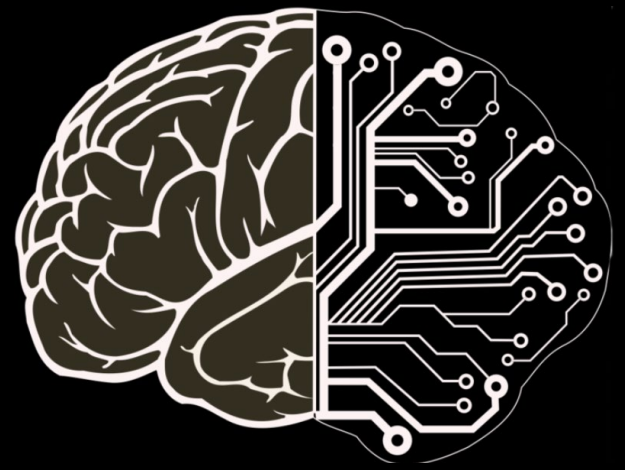
Scaife & Rogers

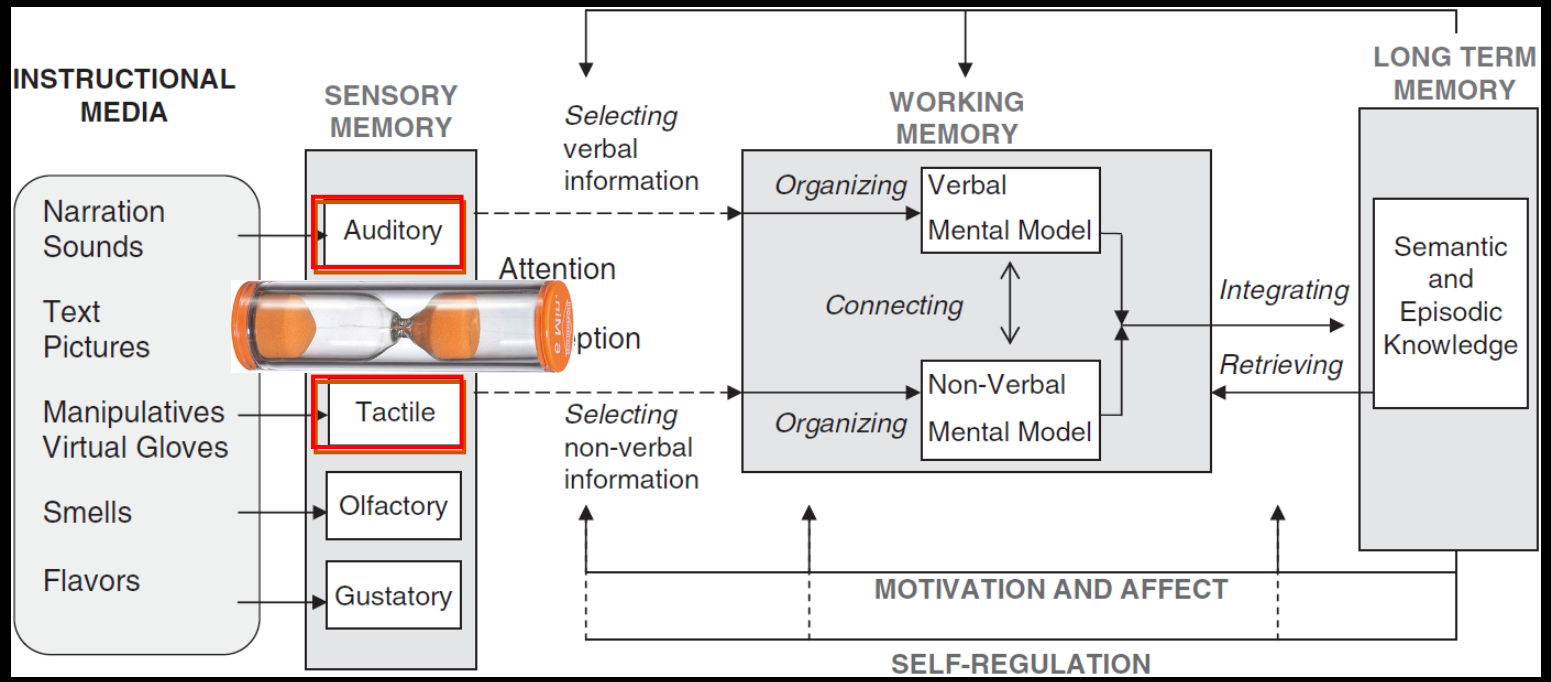
# Emergence of Visualization in Education

COGNITION AND INSTRUCTION, 1991, 8(4), 293-332

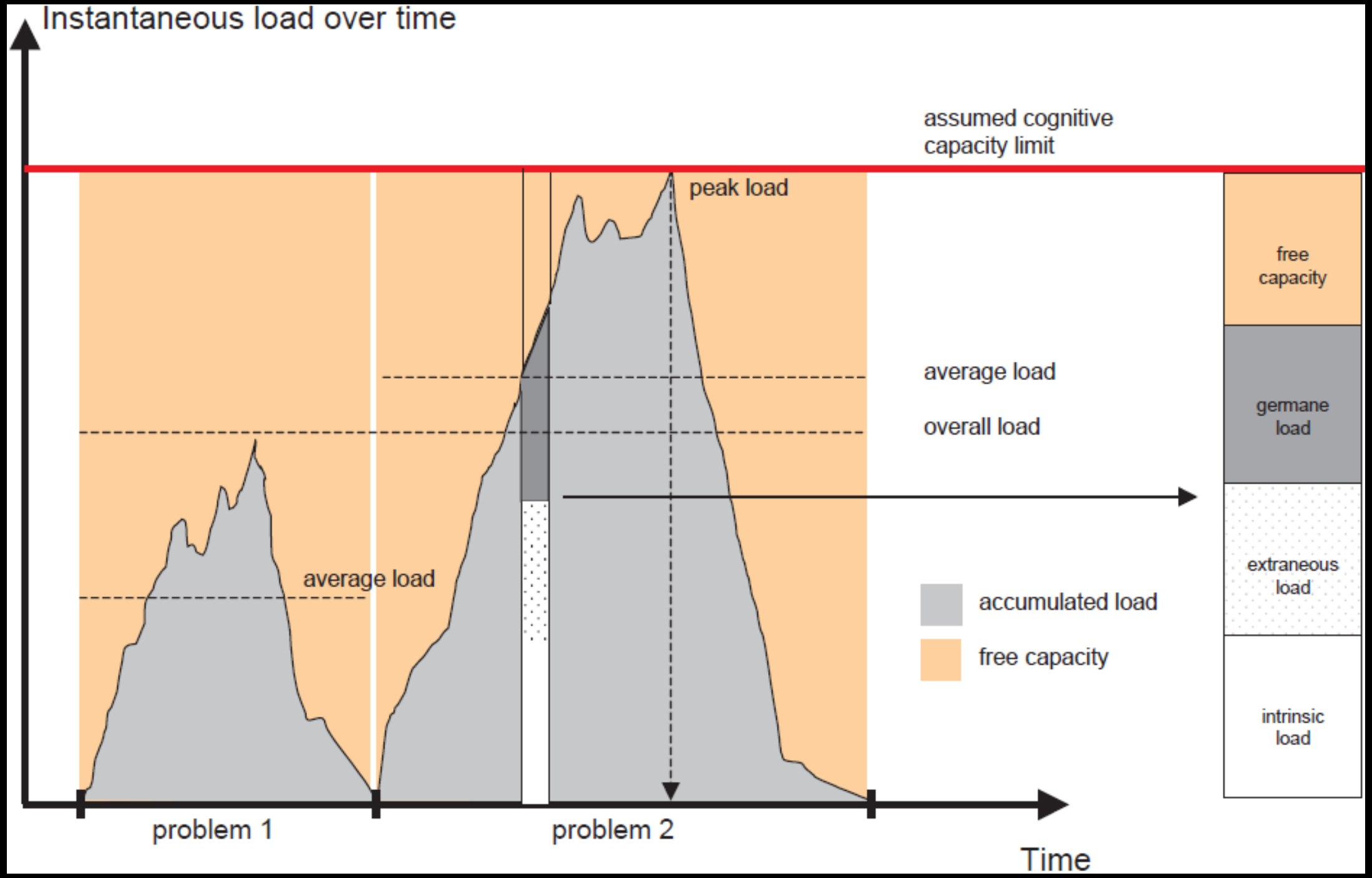

## Cognitive Load Theory and the Format of Instruction

Paul Chandler and John Sweller
*University of New South Wales*

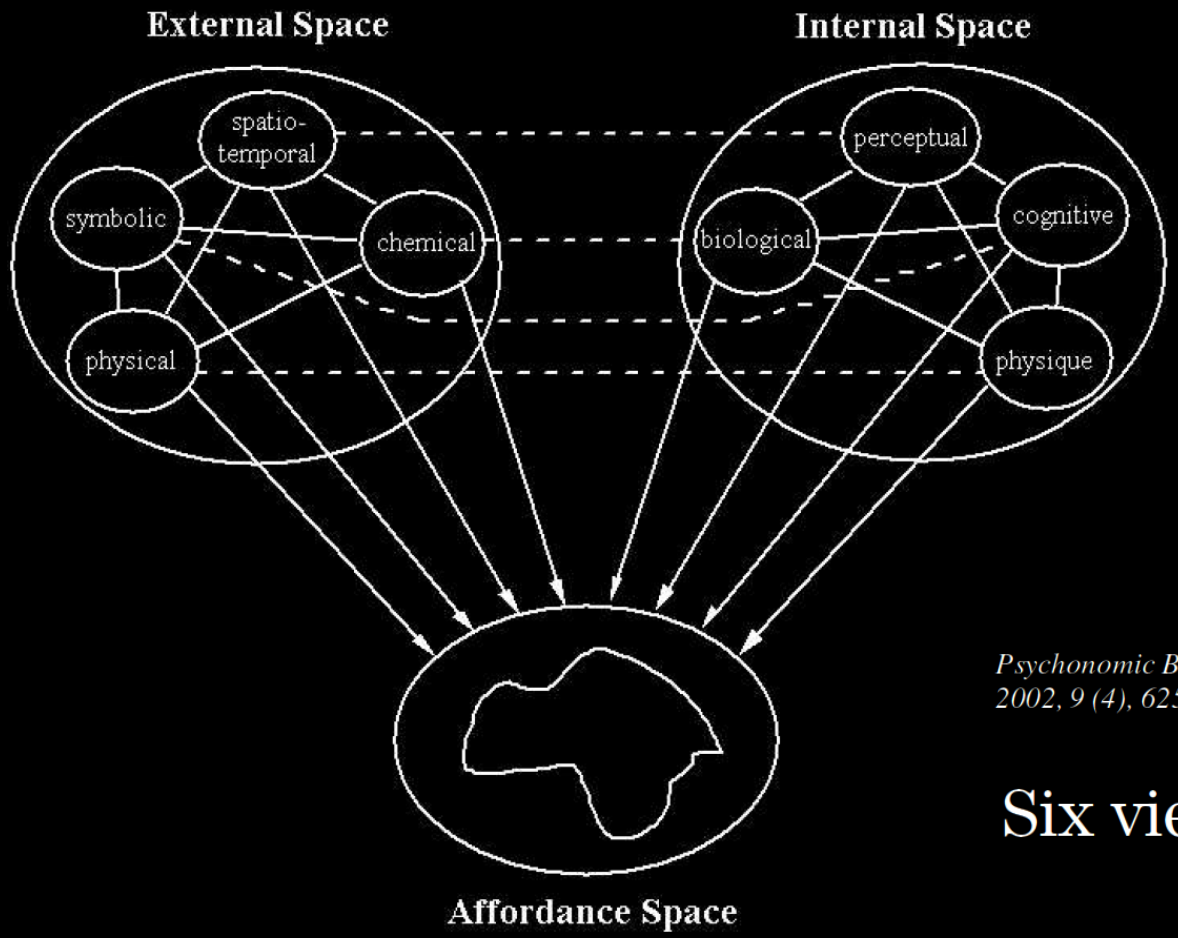






- Sweller
- Mayer
- Lowe
- Ainsworth
- Gilbert
- Treagust


Instantaneous load over time
assumed cognitive capacity limit
peak load
average load
overall load
average load
accumulated load
free capacity
problem 1
problem 2
Time
free capacity
germane load
extraneous load
intrinsic load

# Visualization: Beyond Information-Processing




Zhang & Norman

Kozma

Airey & Linder

Wilson

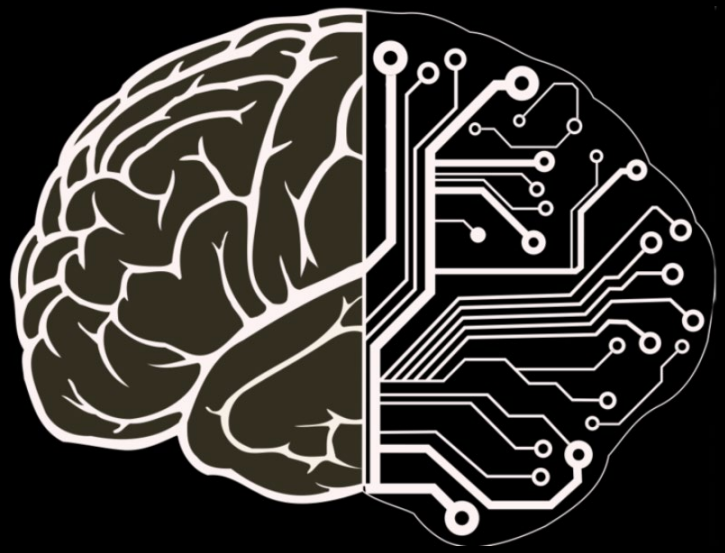
(Kersting)

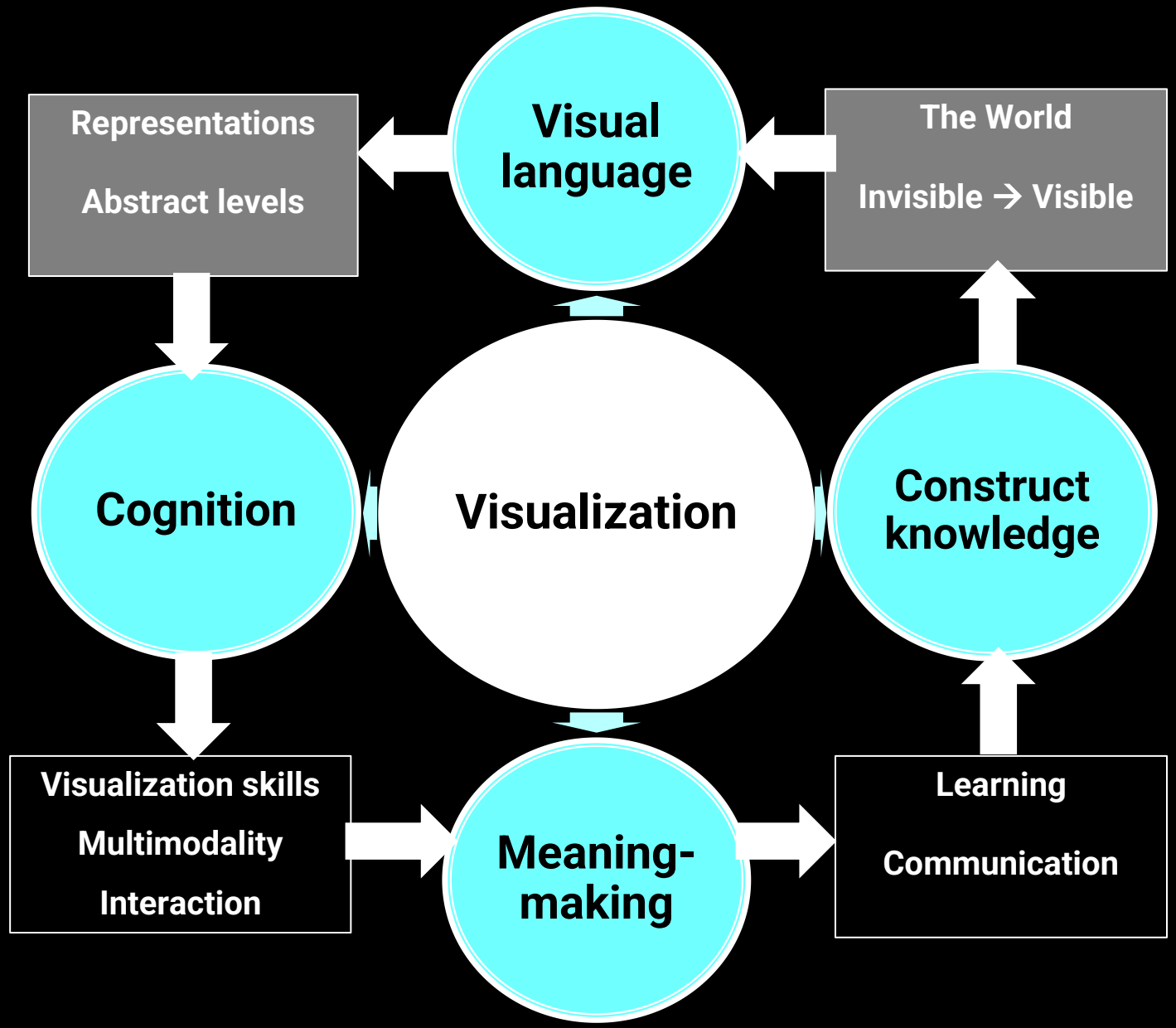
*Psychonomic Bulletin & Review*
*2002, 9 (4), 625-636*

Six views of embodied cognition

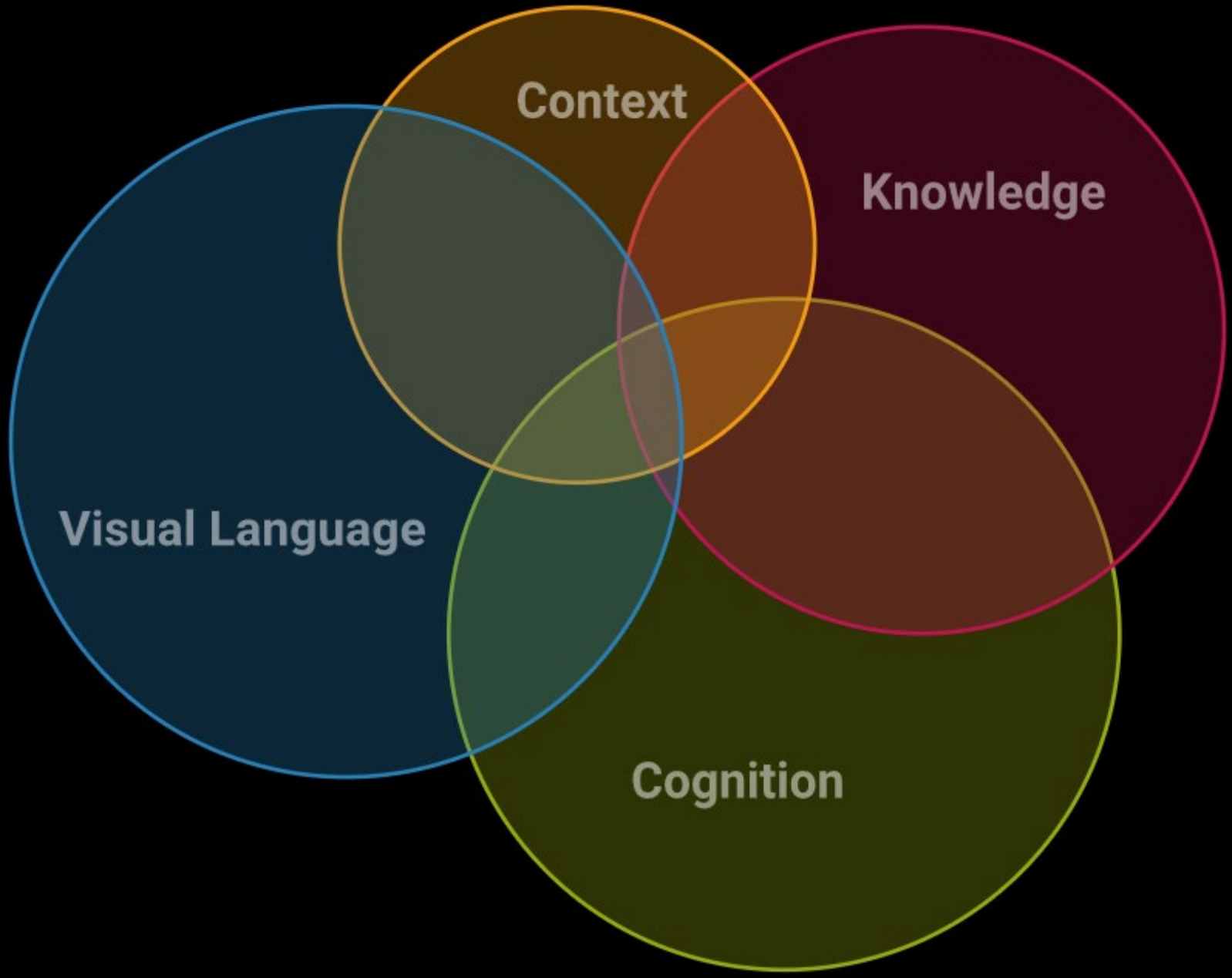
MARGARET WILSON
*University of California, Santa Cruz, California*

# Visual Communication in Education: Theoretical Drivers

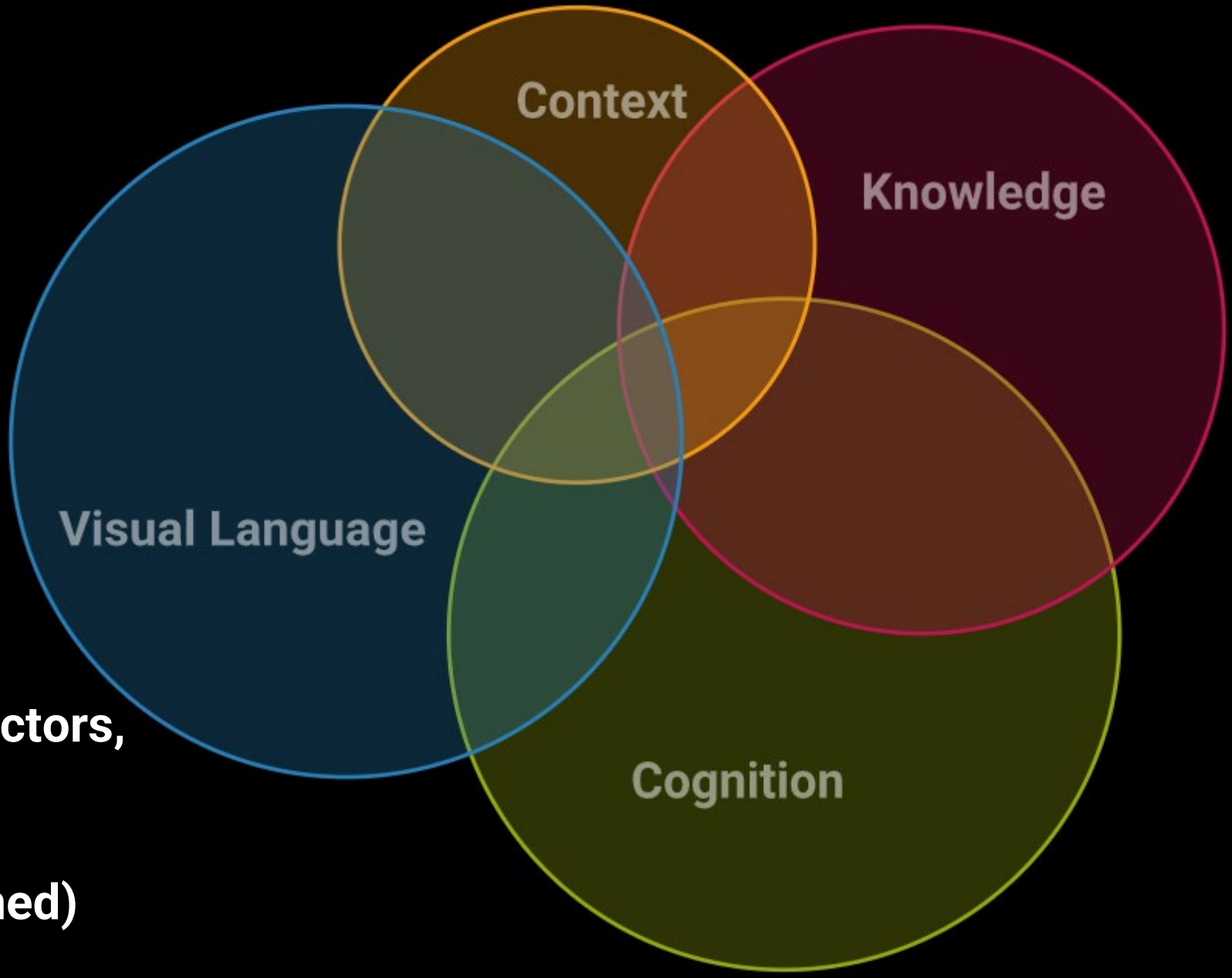



Representations
Abstract levels
Visual language
The World
Invisible → Visible
Cognition
Visualization
Construct knowledge
Visualization skills
Multimodality
Interaction
Meaning-making
Learning
Communication

**How does Visualization Influence Learning and Communication?**

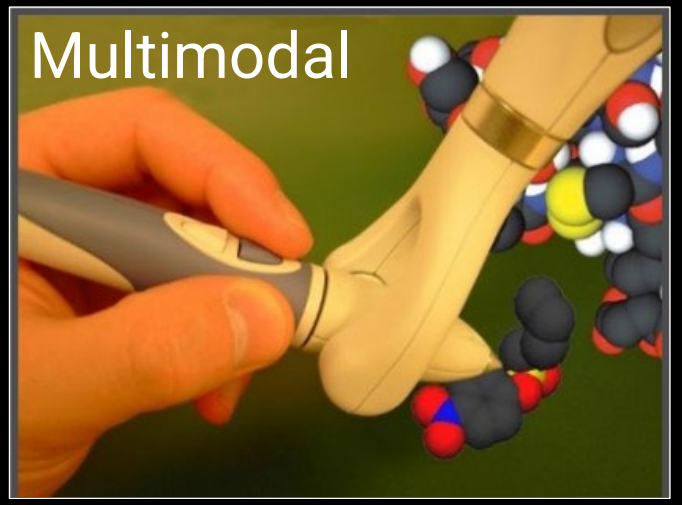


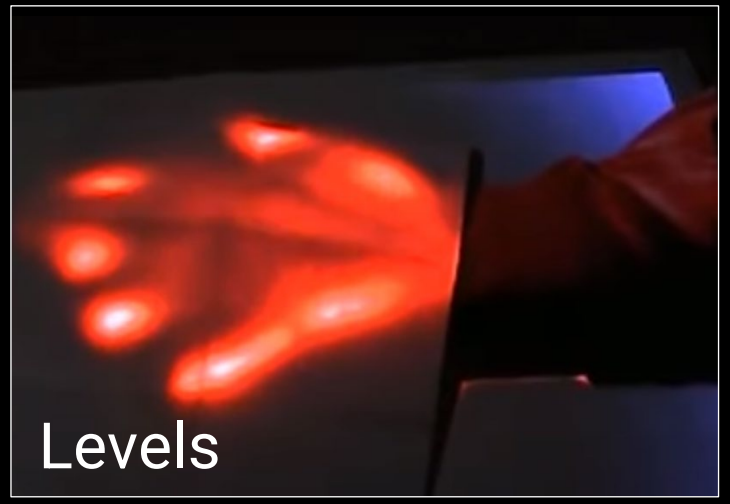
- Introductions
- How might each of these factors, and/or their relationships influence intended communication in a (designed) visualization environment?



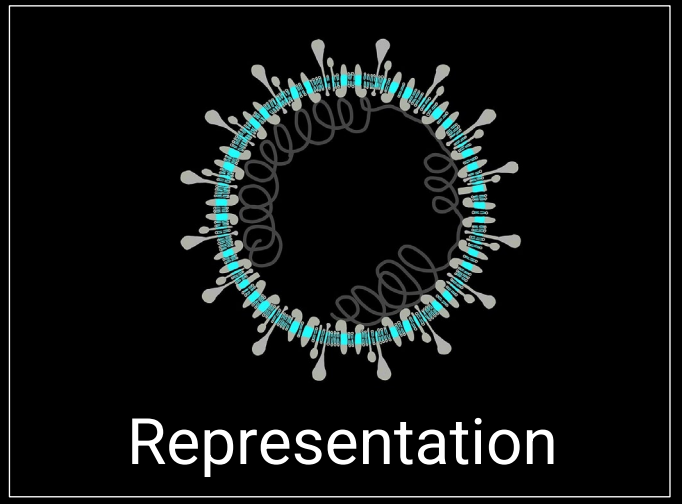
# Interactive Visualization: Making the Invisible Visible

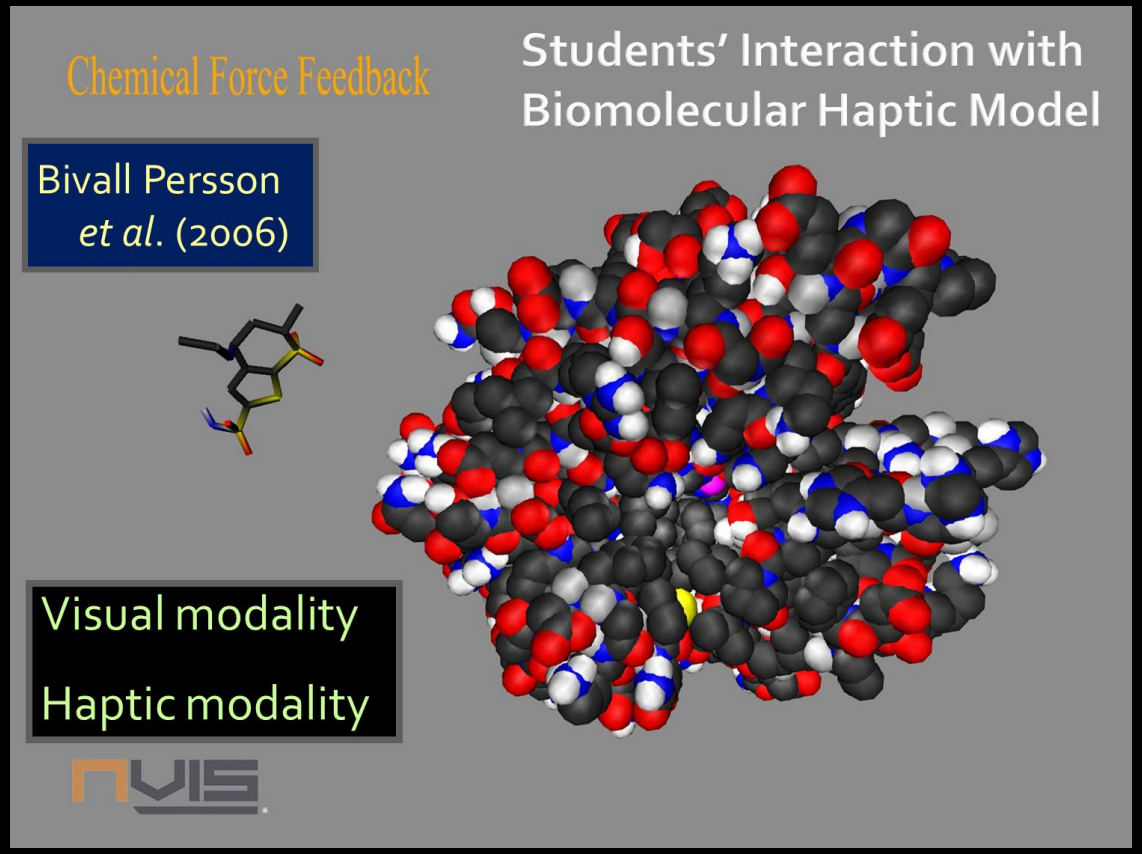











# Relationships between Interaction and Learning?

| | Haptics | No haptics |
|---|---|---|
| Task accuracy | 4.9 | 5.2 |
| Learning gain (%) | +15.0 | +4.0 |

*ANOVA; p<.03*

Schönborn, Bivall, & Tibell (2011); Bivall (2010)

# Logging Interactive Behaviours

```
1164209971:
P: 0.232644 0.031359 0.004198
M: 0.988495 0.123225 -0.087714 -0.011762 0.640774 0.767640 0.1
F: -0.400591 0.090579 -0.147982
1164209973:
P: 0.198945 0.012187 0.016906
M: 0.987767 0.131555 -0.083727 -0.019272 0.635791 0.771621 0.1
F: -1.761650 0.388271 -0.706596
1164209975:
P: 0.204566 0.009074 0.033348
M: 0.989168 0.126947 -0.073690 -0.021983 0.624485 0.780727 0.1
F: -0.624909 0.179189 -0.368426
1164209979: WRITE FILE: docked_state_1164209979.pdb
```

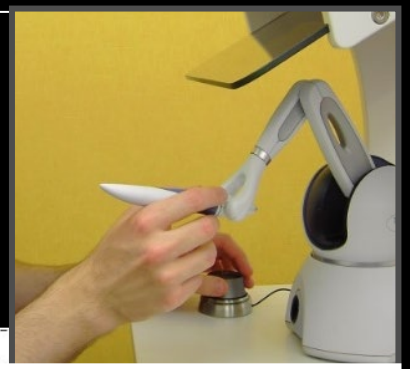
Time-stamped samples

3D-position

Force magnitude

```
1164206840: INIT GRIP CHANGE
1164206840:
R: 0.770937 -0.110657 0.627225 0.228893 0.967135 -0.110713
1164206840:
R: 0.771492 -0.103770 0.627719 0.220882 0.968929 -0.111296
1164206840:
R: 0.772260 -0.093648 0.628366 0.207960 0.971848 -0.110744
1164206840:
R: 0.770146 -0.066869 0.634353 0.169314 0.980246 -0.102228
1164206840:
R: 0.771406 -0.065049 0.633010 0.163731 0.981559 -0.098662
1164206841:
R: 0.761481 -0.042182 0.646813 0.132500 0.986939 -0.091627
1164206841: EXIT GRIP CHANGE
```

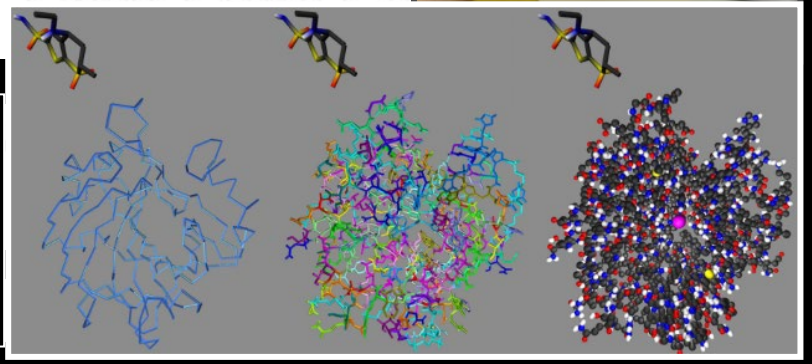
Grip change: Angle of attachment



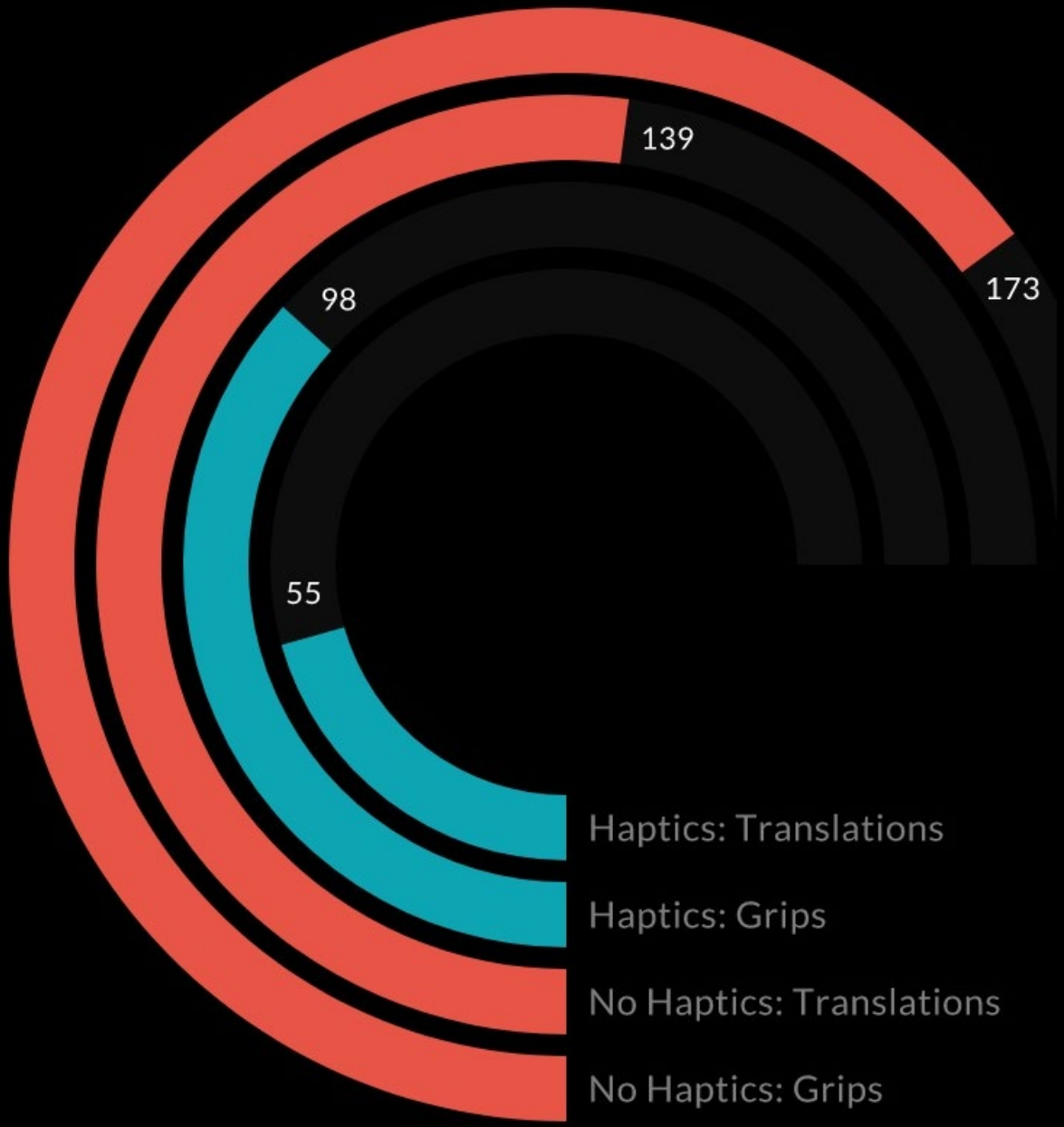
```
P: -0.048559 0.702321 -0.230569
M: 0.893688 0.203151 -0.400063 0.19
F: 7.664154 -21.872881 39.318600
1164286610: DRAW STYLE CHANGED TO 2
1164286610: DRAW STYLE CHANGED TO 3

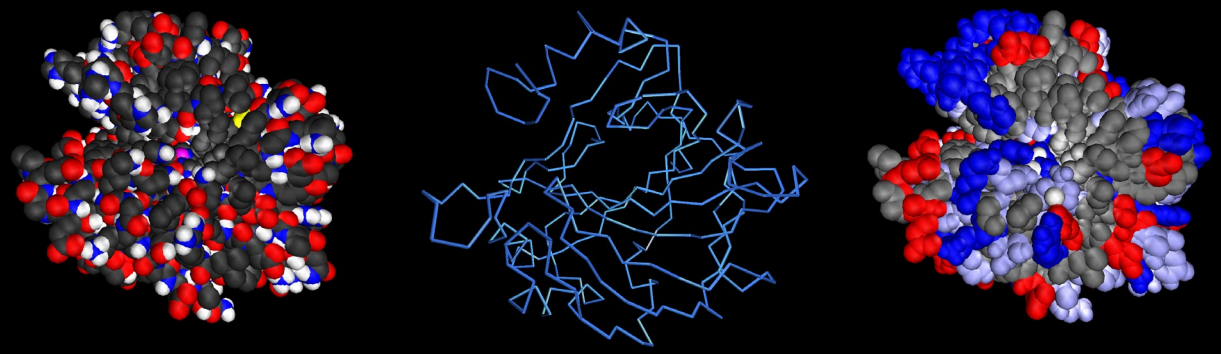
1164200651: COLOR MODE CHANGED TO 2
1164200653: COLOR MODE CHANGED TO 3
```

Visual Represent. Switches



# Relationships between Interaction and Learning?



Schönborn, Bivall, & Tibell (2011)


NANO
NANO
FRÅGA EN FORSKARE

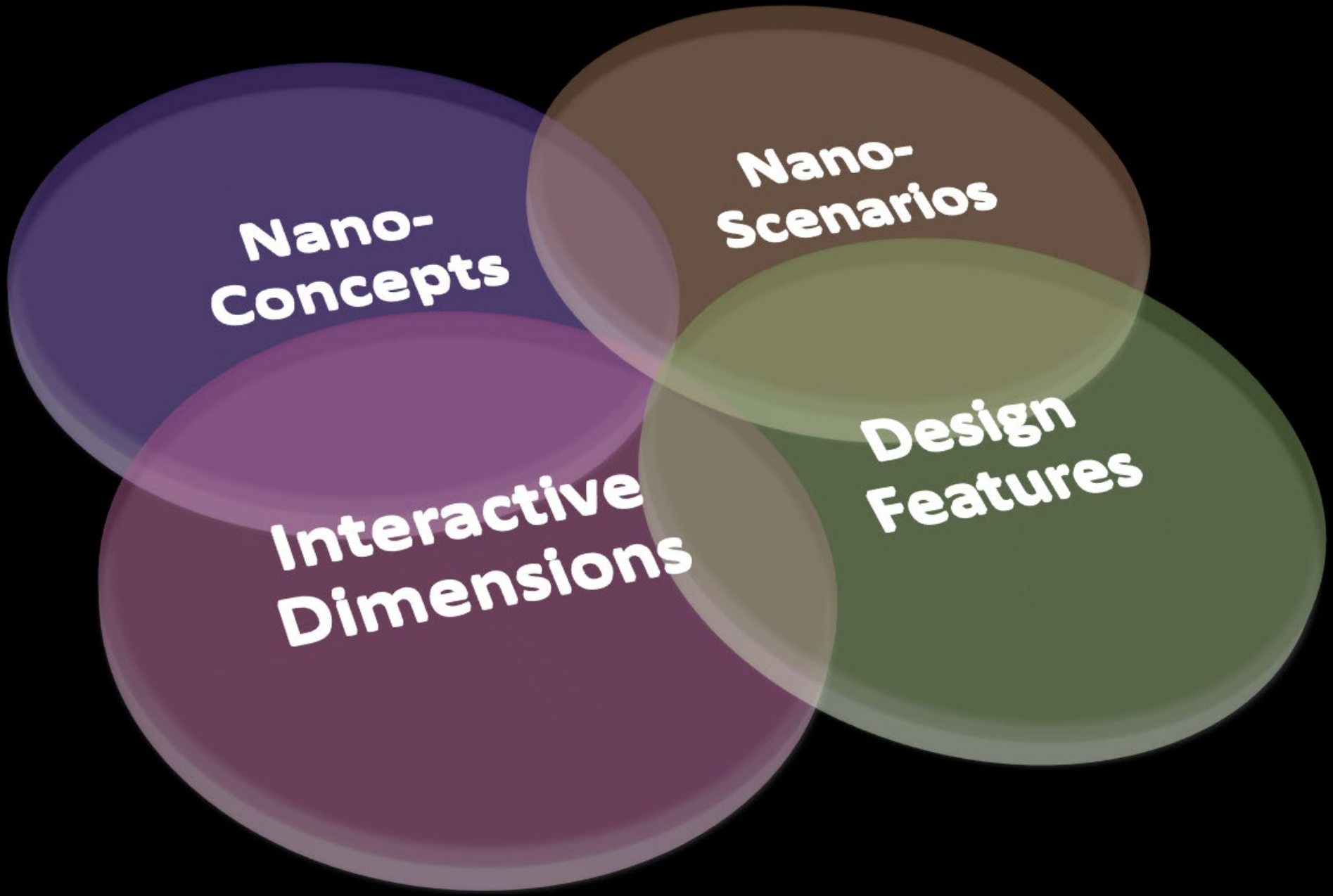
# Gesture-based Interactions for Accessing the Nanoworld

- Core science concepts
- STEM
- Public understanding

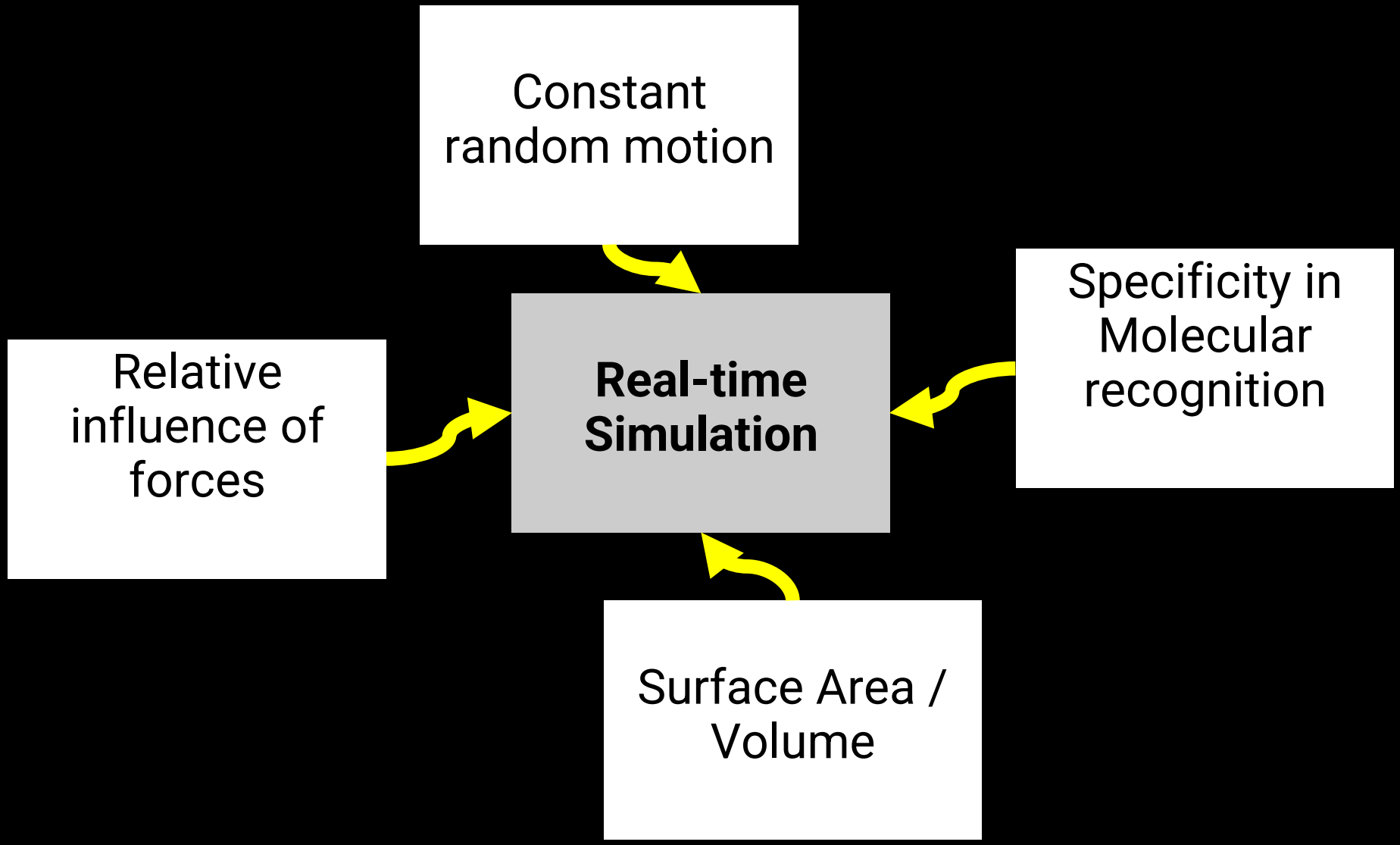
Swedish Research Council

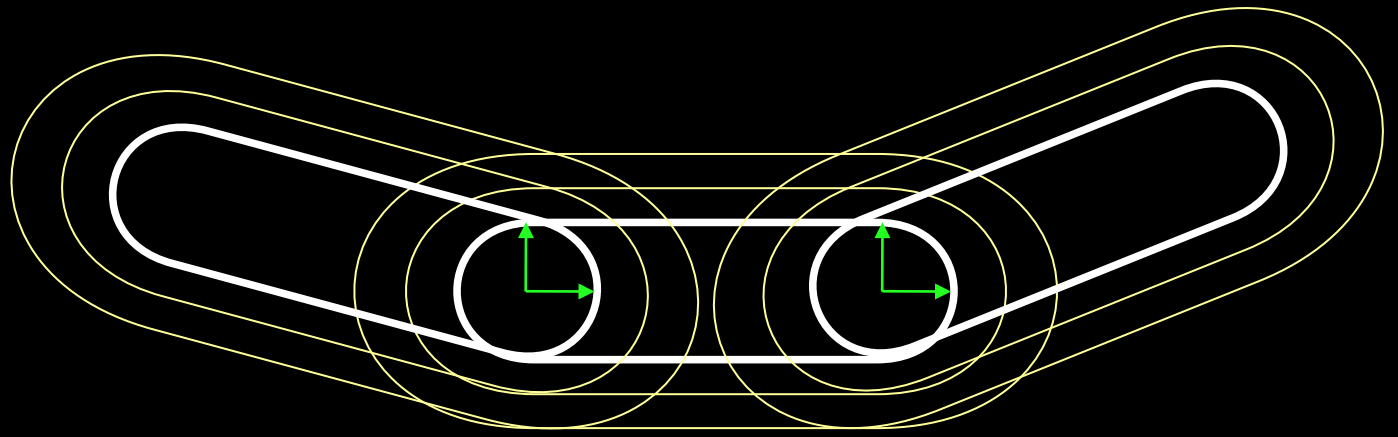
e.g. Schönborn, Höst, & Palmerius (2016); Palmerius, Schönborn, & Höst (2012); Flint, Palmerius, Höst, & Schönborn (2020)

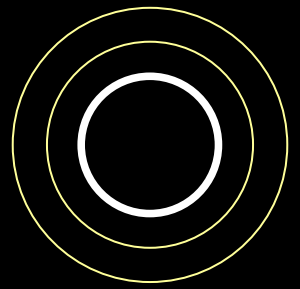

CARBON NANOTUBES
IKOLNANORÖR

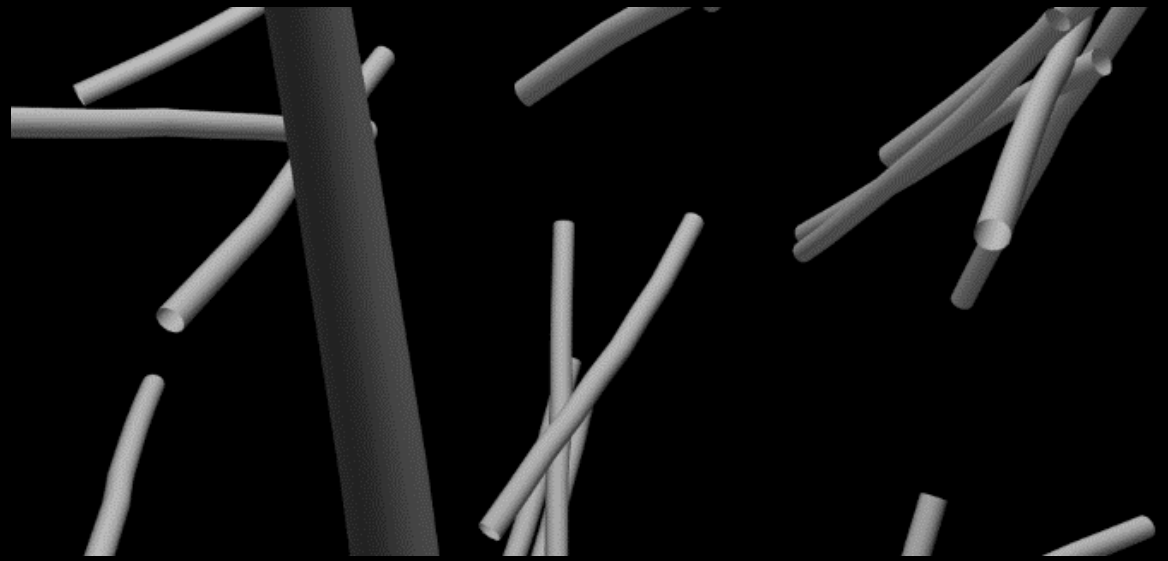

Nano-
Concepts
Nano-
Scenarios
Interactive
Dimensions
Design
Features

# Communicating Nano-Concepts

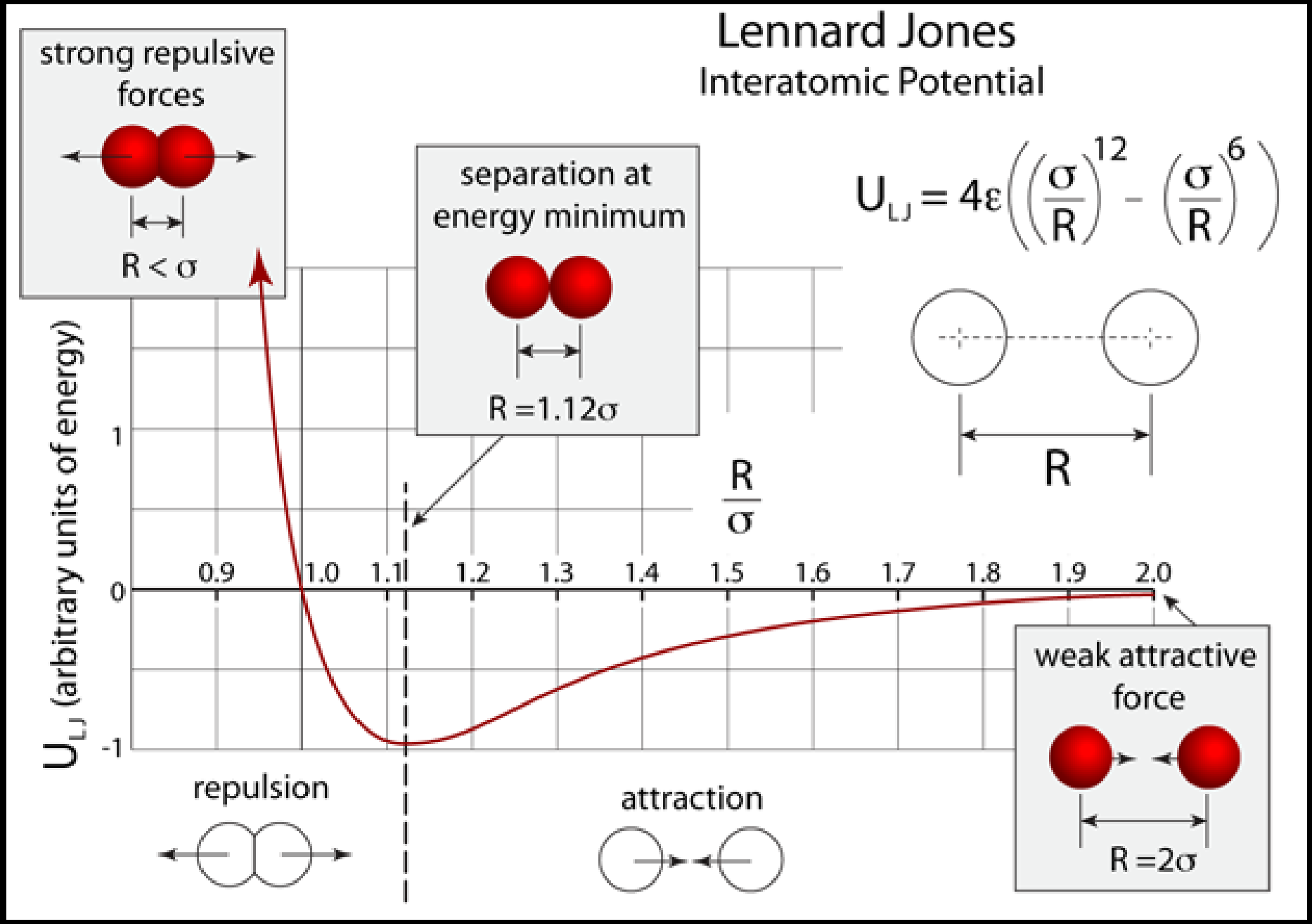




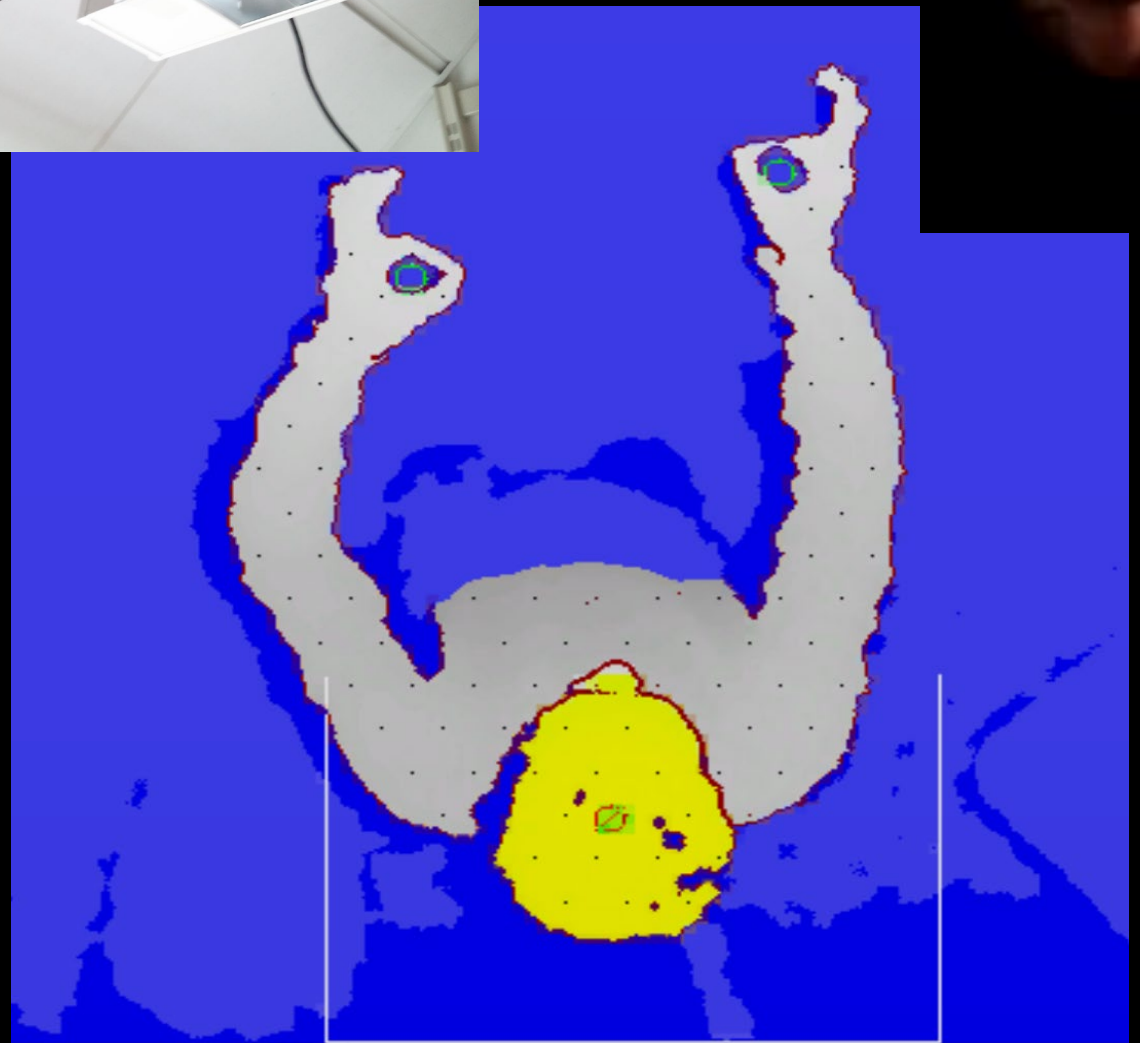




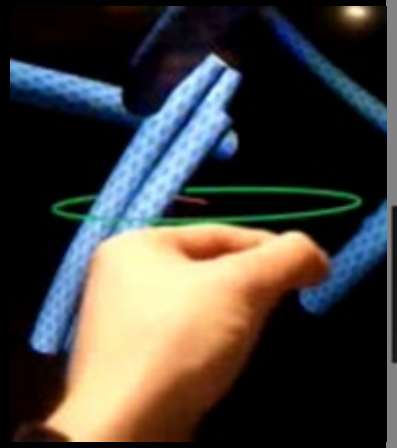
CRESEARCH

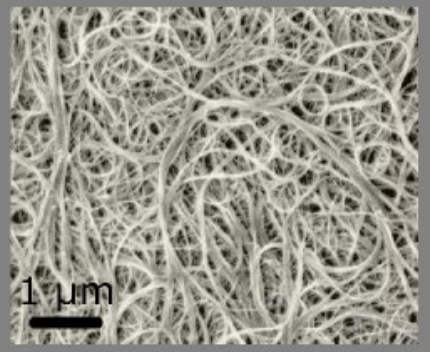

Lennard Jones
Interatomic Potential
$U_{LJ} = 4\varepsilon\left(\left(\frac{\sigma}{R}\right)^{12} - \left(\frac{\sigma}{R}\right)^{6}\right)$
strong repulsive forces
R < σ
separation at energy minimum
R =1.12σ
R
R/σ
$U_{LJ}$ (arbitrary units of energy)
1
0
-1
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
repulsion
attraction
weak attractive force
R =2σ

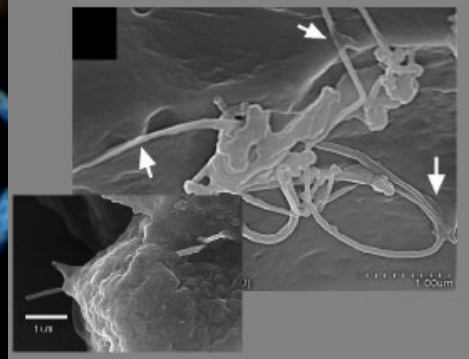

XBOX 360

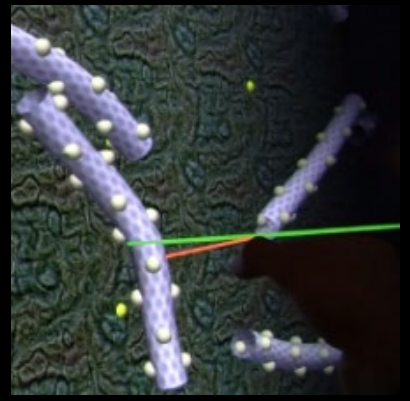


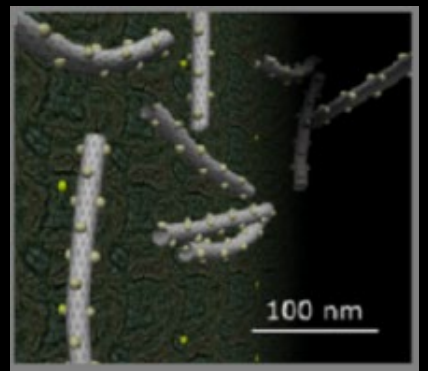
# Communication of Risk and Benefit

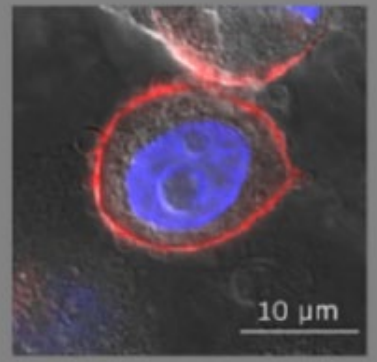


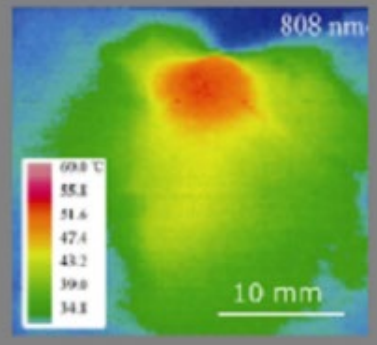


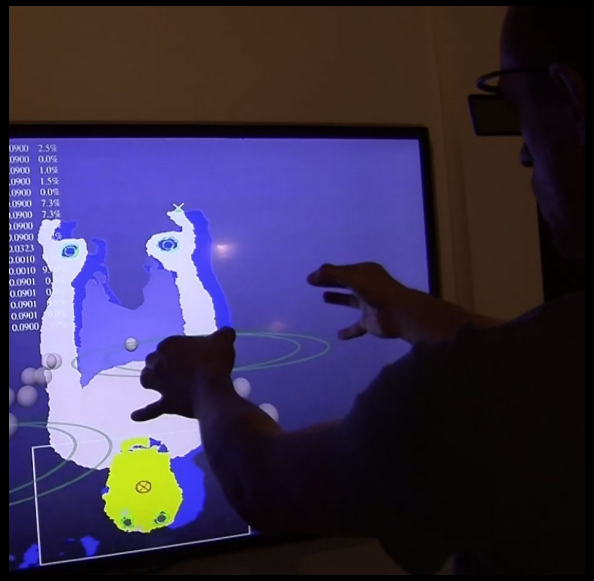


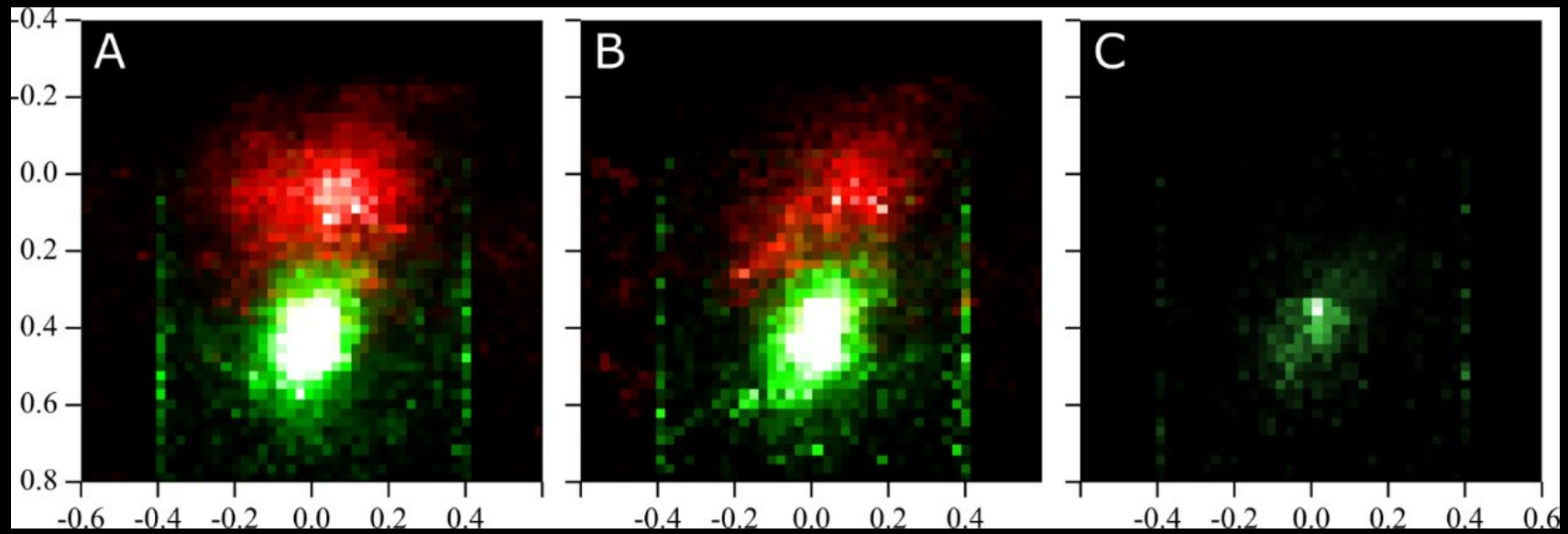


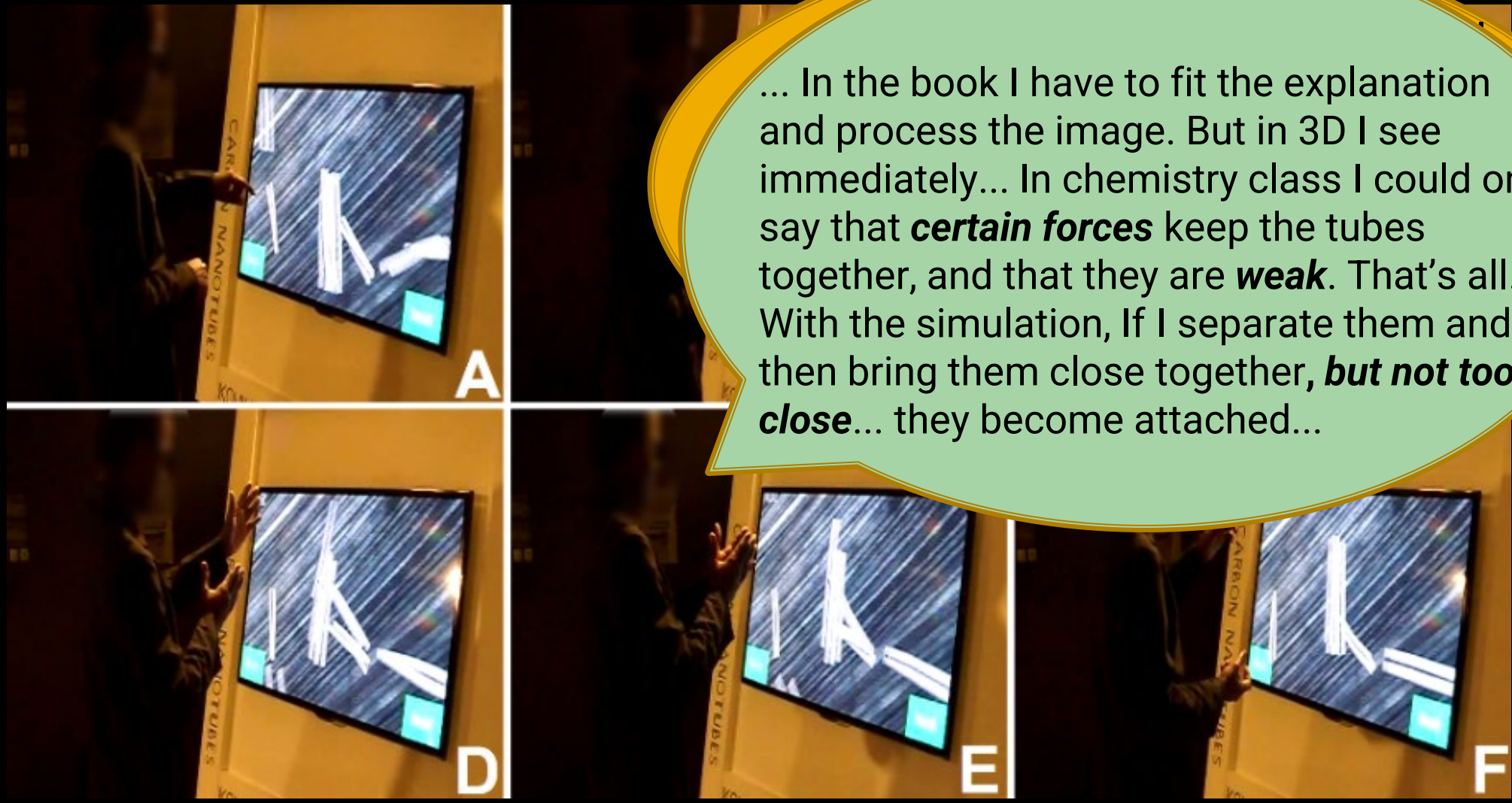
# Logged Interaction in a Virtual Nanoworld






| Logged variable | Nano-toxicity | Nano-therapy |
|---|---|---|
| *Total user activations* | 816 sessions | 448 sessions |
| *Ave. time spent in scenario* | 53.4 sec. | 49.8 sec. |
| *Ave. "grab" time in scenario* | 34.4 sec. | 27.0 sec. |
| *Ave. grab path-length* | 33.0 cm | 31.6 cm |

# Clinical “Think Aloud”




... In the book I have to fit the explanation and process the image. But in 3D I see immediately... In chemistry class I could only say that ***certain forces*** keep the tubes together, and that they are ***weak***. That’s all. With the simulation, If I separate them and then bring them close together, ***but not too close***... they become attached...

# Reaching into the Virtual to reveal the Invisible

| | |
|---|---|
| *A modified nanotube attached to its specific target will not remain permanently bound* | **0,71** |
| *Nanotubes spontaneously aggregate together into rope-like structures* | **0,61** |
| *A nanometer is 1 000 000 000 (1 billion) times smaller than a meter* | **-0,05** |
| *Nanotech. allows scientists to arrange atoms in ways that don't already occur in nature* | **-0,03** |

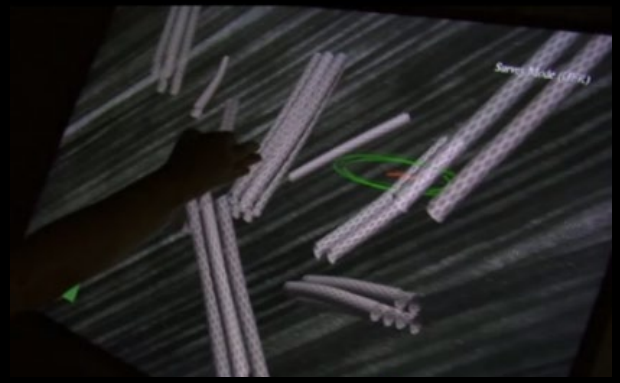
e.g. Schönborn, Höst, & Palmerius (2016); Palmerius, Schönborn, & Höst (2012); Flint, Palmerius, Höst, & Schönborn (2020)

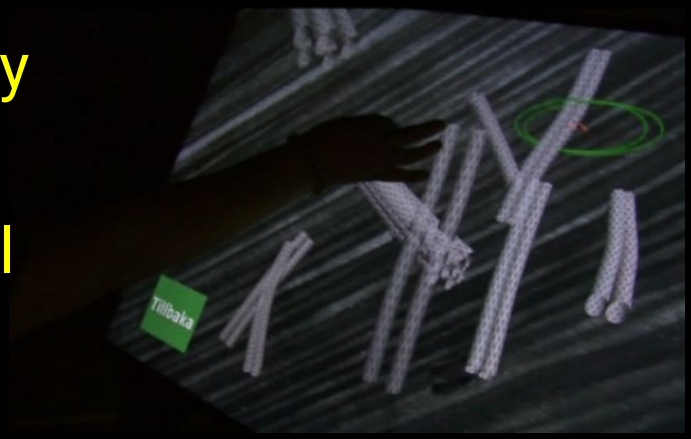
# Qualitative Insights

- S: I want to touch them, it feels like they are there soaring in front of me [...] That is why I think that this is so fascinating... you think something is really there but it isn't. [*04:47-05:21*]

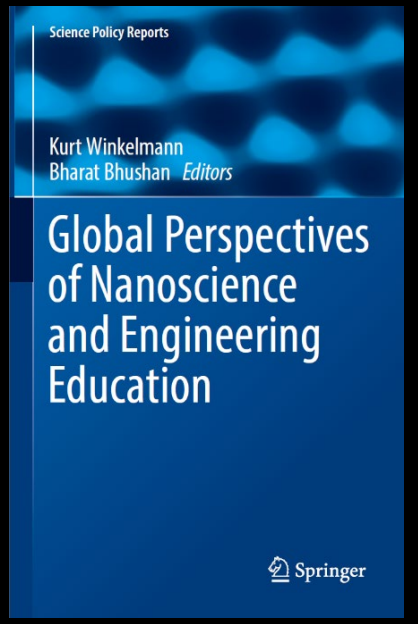
- S: I feel something, is it possible?
  I: You said that you feel like you felt something?
  S: Like, eh, in my hand, in my hands. [*07:34-08:06*]
- S: They want to have a big surface [in contact]... Yes, I got that knowledge now when I can actually move them. [*05:52-06:18*]

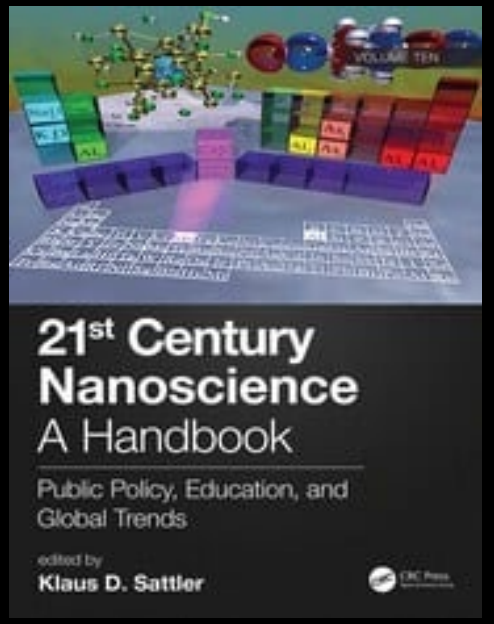
- S: To get them off the surface I really have to pull them away... I really have to grab them to get them off the [cell] wall. [*12:30-13:57*]





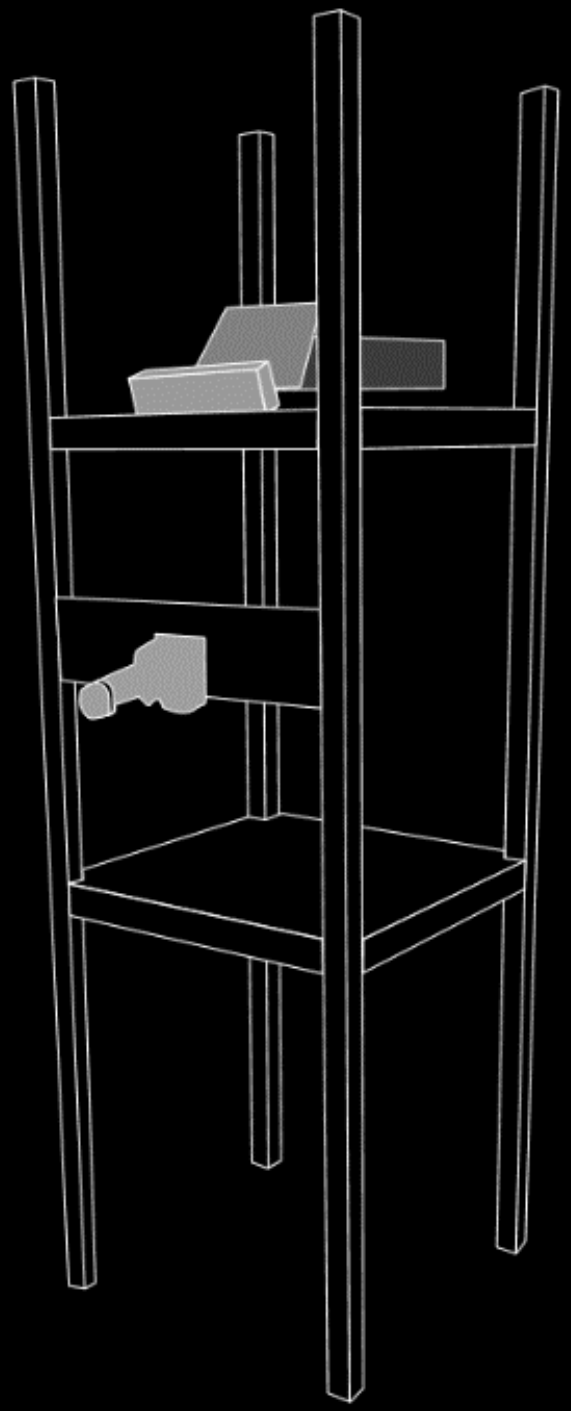
# Linking Bodily Action and Perception



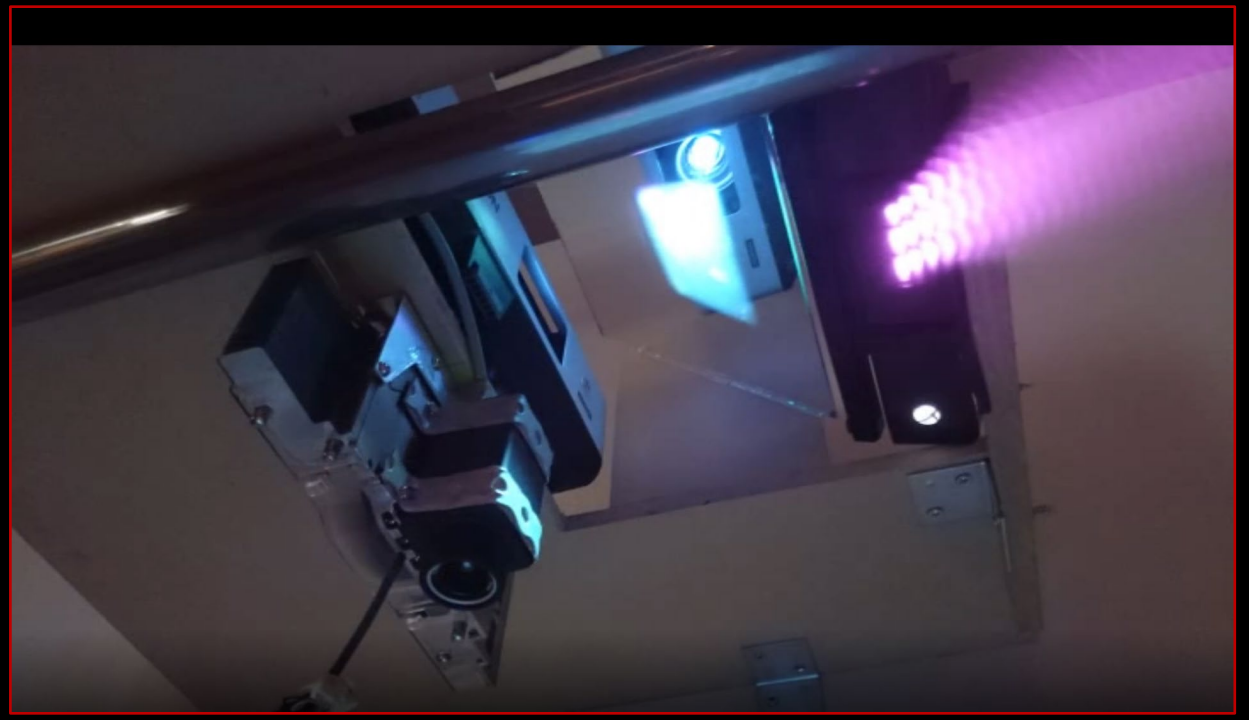




- Presence and immersiveness
- Nano without the jargon
- Pseudohaptic perception
- Anthropomorphic language

Schönborn, Höst, & Lundin Palmerius (2016); Flint, Lundin Palmerius, Höst, & Schönborn (2021)

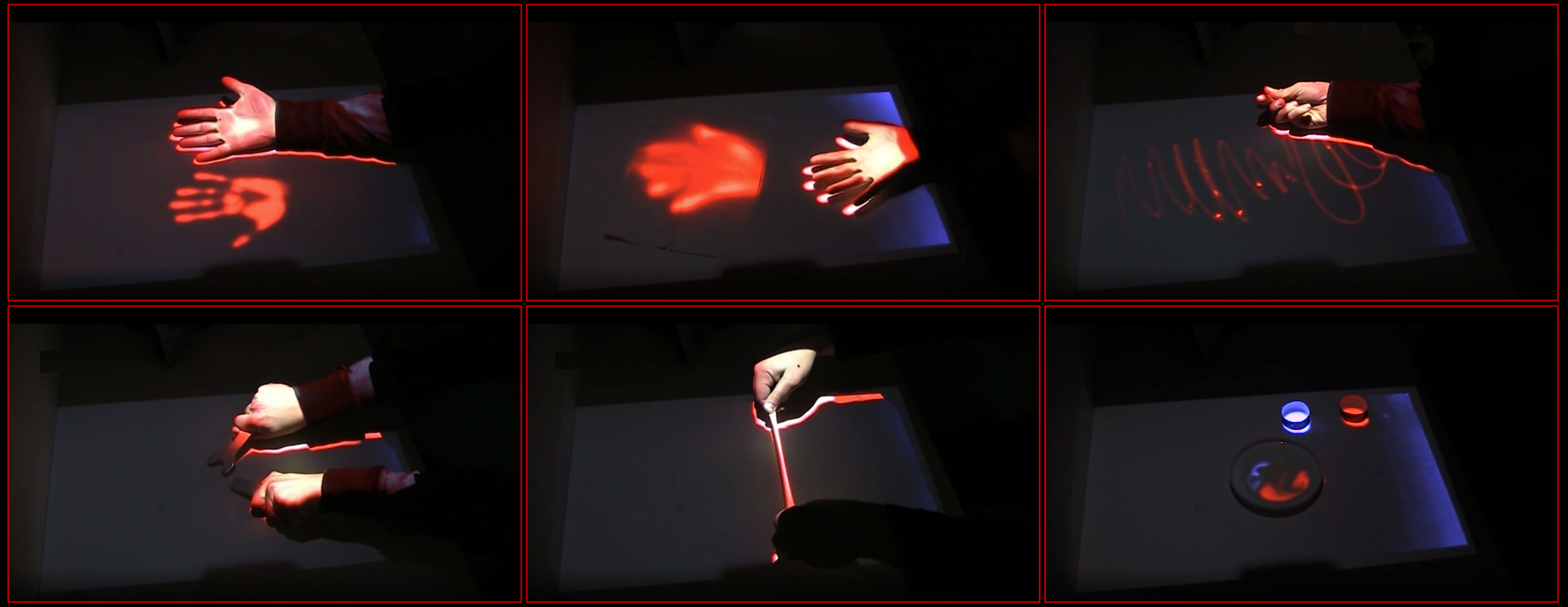


# Visually Augmenting the Physical to Reveal the Invisible



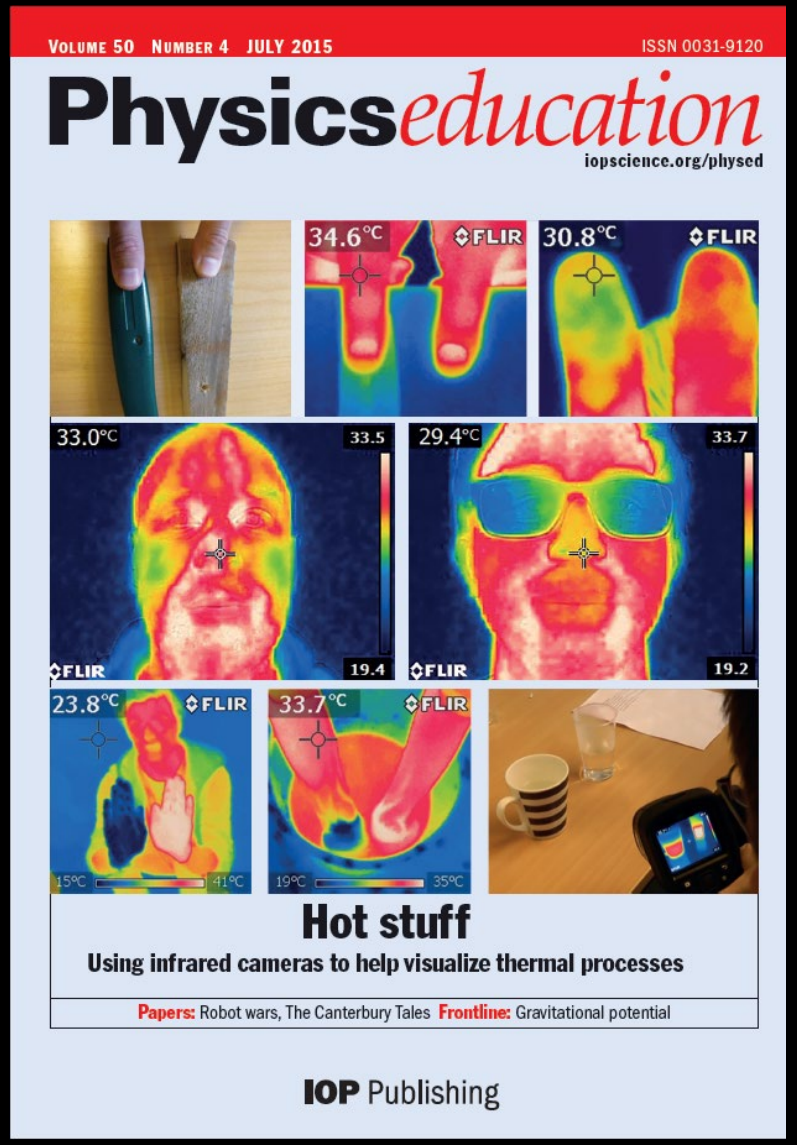
Palmerius & Schönborn
(In Press, 2016)

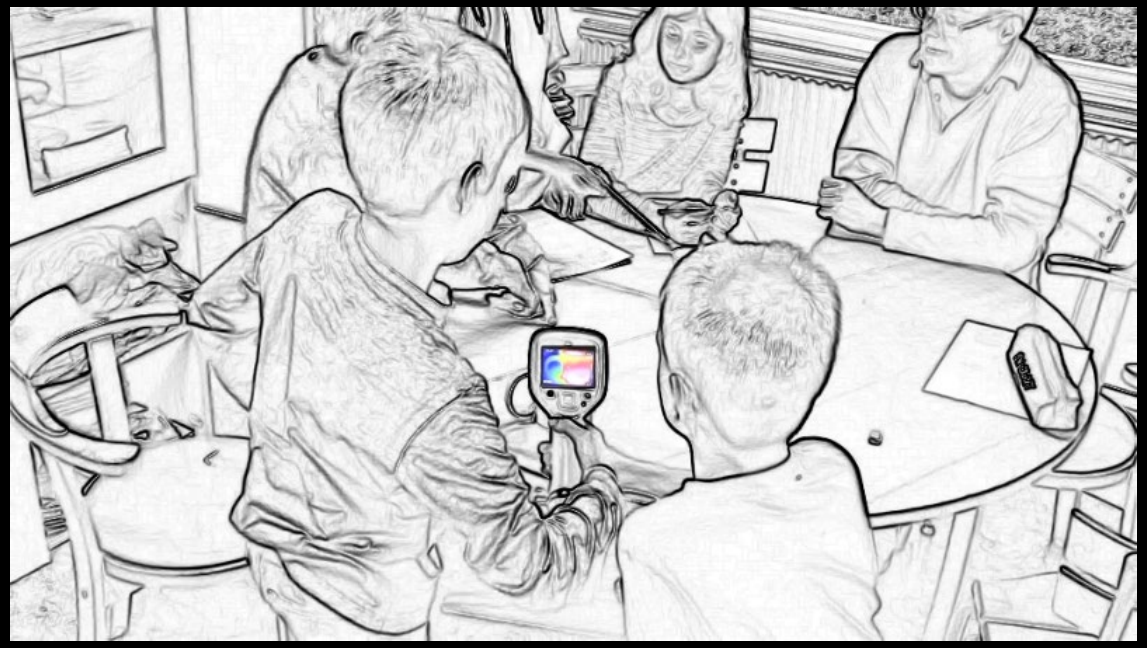
# Interactive Visualization: Communicating the Invisible



Palmerius & Schönborn
(In Press, 2016)

# New Semiotic Opportunities: Communicating the Invisible

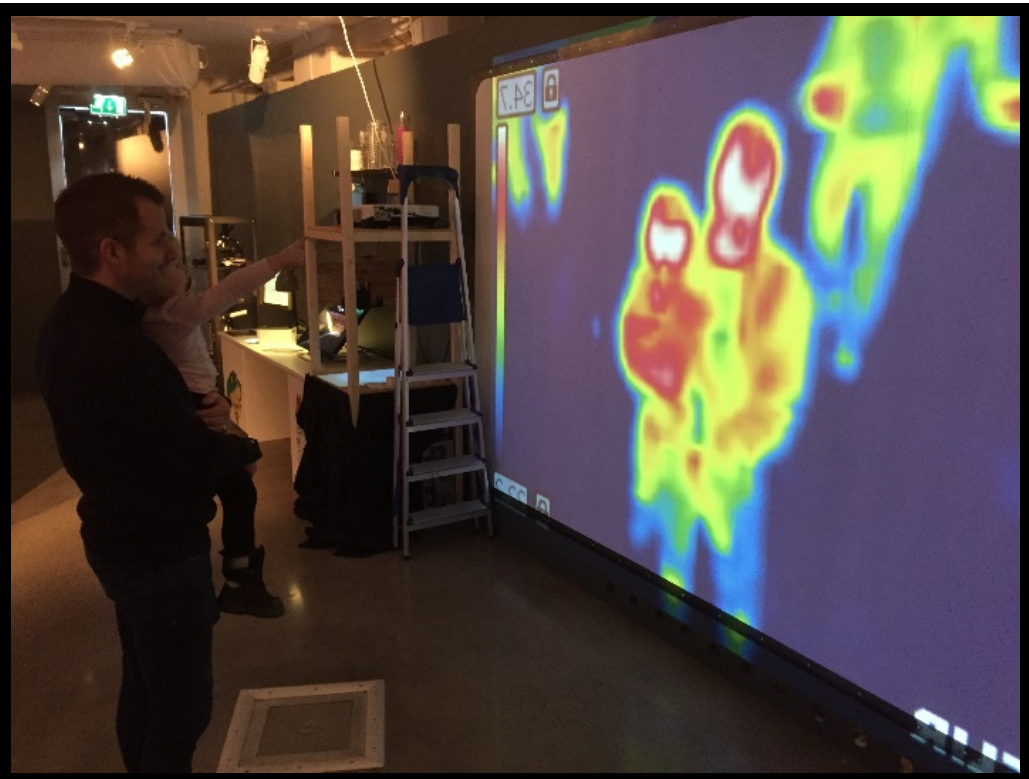


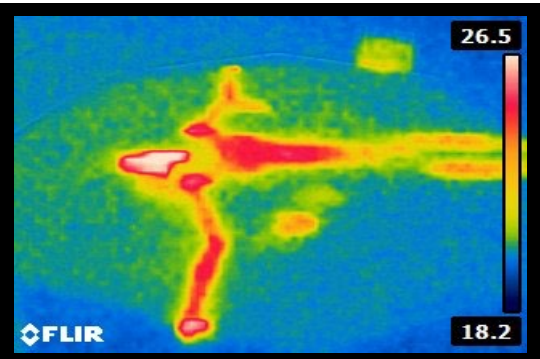



- POE method
- Instant inquiry

*e.g.* Schönborn, Haglund, & Xie, (2014); Haglund, Jeppsson, Schönborn (In Press, 2016)

# New Semiotic Opportunities: Communicating the Invisible





- Multimodal experiences of heat
- Primary metaphors

*e.g.* Schönborn, Haglund, & Xie (2014); Palmerius, & Schönborn (2016); Larsson, Stafstedt, & Schönborn (2017)

Innovations in Science Education and Technology 26

Jesper Haglund · Fredrik Jeppsson · Konrad J. Schönborn *Editors*

## Thermal cameras in science education

This book presents a collection of educational research and developmental efforts on the rapidly emerging use of infrared cameras and thermal imaging in science education. It provides an overview of infrared cameras in science education to date, and of the physics and technology of infrared imaging and thermography. It discusses different areas of application of infrared cameras in physics, chemistry and biology education, as well as empirical research on students' interaction with the technology. It ends with conclusions drawn from the contributions as a whole and a formulation of forward-looking comments.

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Thermal cameras in science education

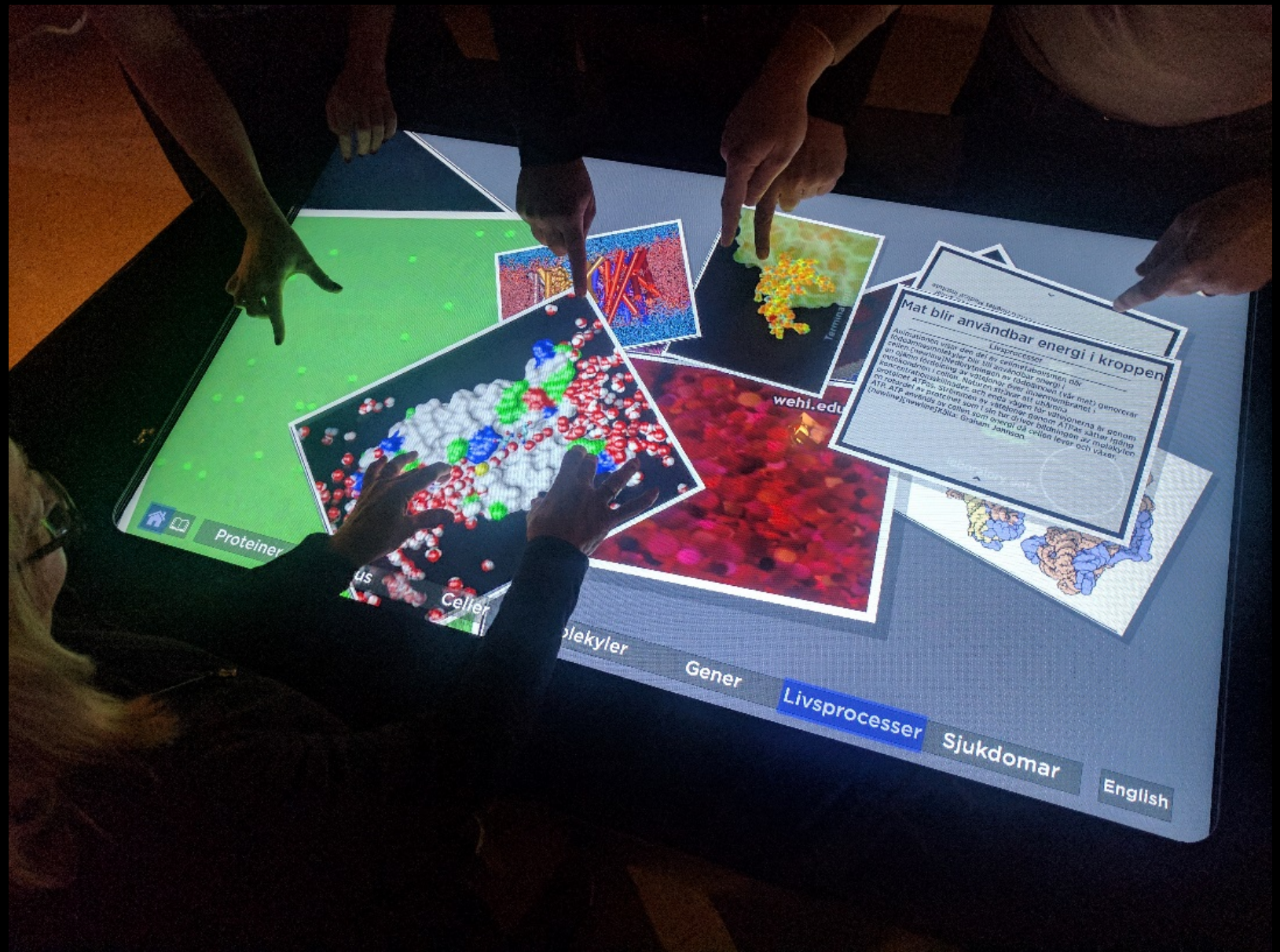
Innovations in Science Education and Technology 26

Jesper Haglund
Fredrik Jeppsson
Konrad J. Schönborn *Editors*

# Thermal cameras in science education

Springer

# Communicating the Microcosmos with Interactive Visualization



# Integrating Content and Interactive Features

- How can visual biological content, interactive features and logging capability be integrated?
- What are public visitors' preferences and patterns of interaction?
- What insight can be gained into how the touch table can support learning in a science center?

NORRKÖPING

e.g. Höst, Schönborn, Fröcklin, & Tibell (2018)

# Integrating Logging and Interactivity

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```

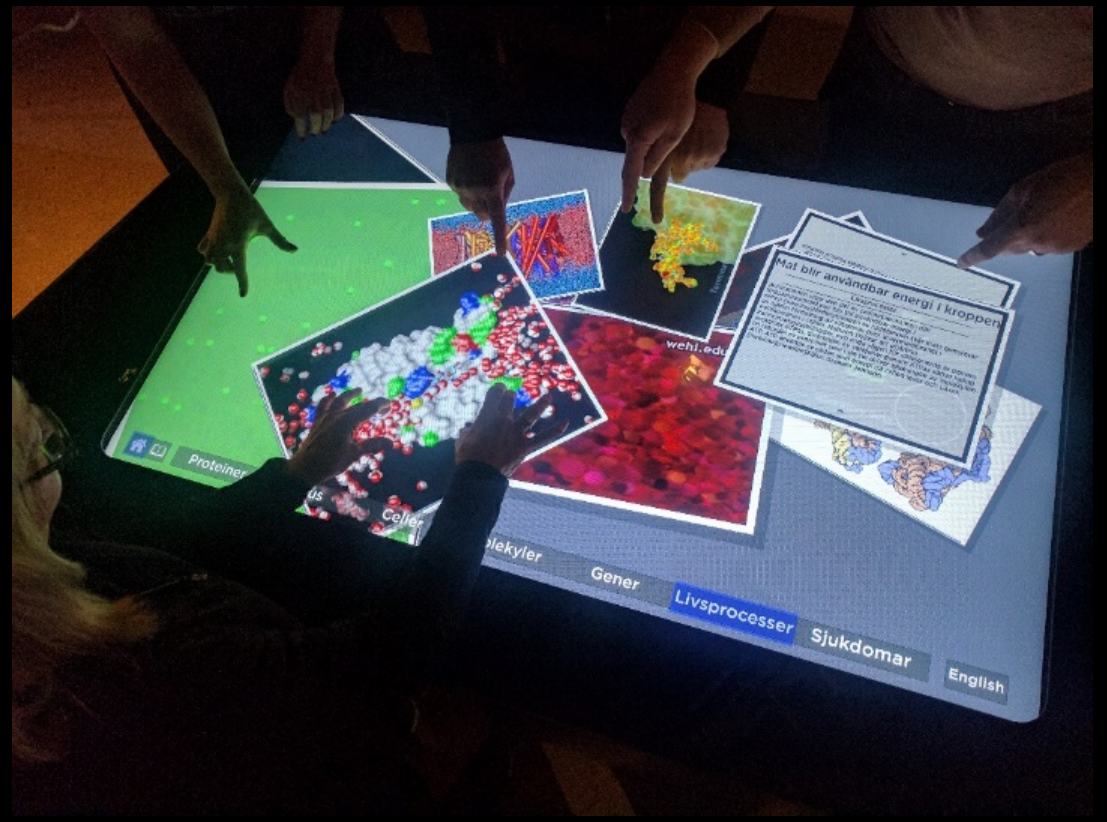
# Integrating Logging and Interactivity

# Preferences and Patterns of Interaction

| *Category* | Total activations | Average activations per session |
|---|---|---|
| ***Viruses*** | 812 | 0.95 |
| ***Cells*** | 687 | 0.80 |
| ***Diseases*** | 677 | 0.79 |
| ***Molecules*** | 673 | 0.78 |
| ***Genes*** | 649 | 0.76 |
| ***Proteins*** | 630 | 0.73 |
| ***Life processes*** | 619 | 0.72 |

# Preferences and Patterns of Interaction

- Attractive power (How often?)
  - Sessions card used
  - Sessions card used first
- Holding power (How long?)
  - Mean number of log entries
- Ranking Score – “Engagement”




e.g. Höst, Schönborn, Fröcklin, & Tibell (2018)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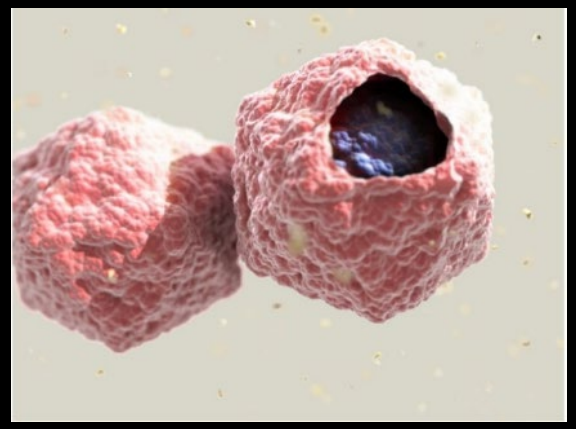
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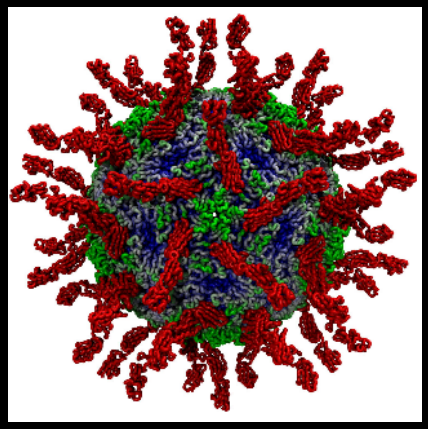
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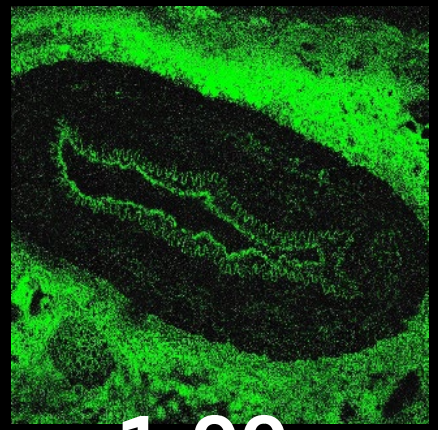
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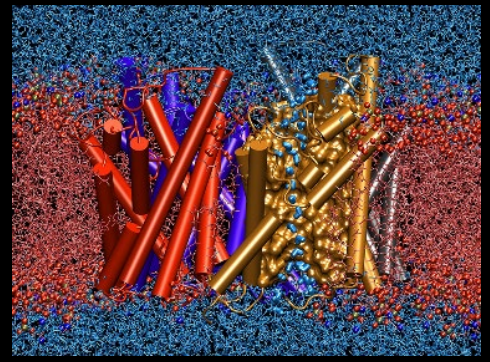
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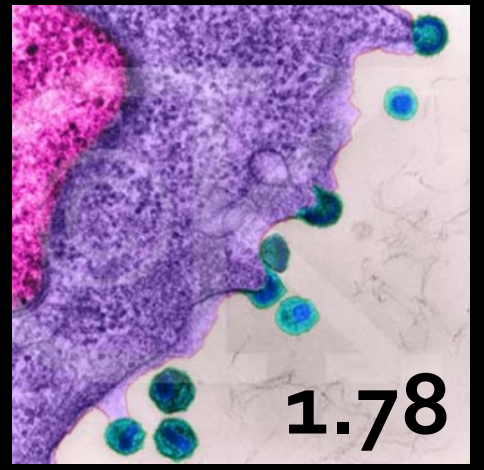
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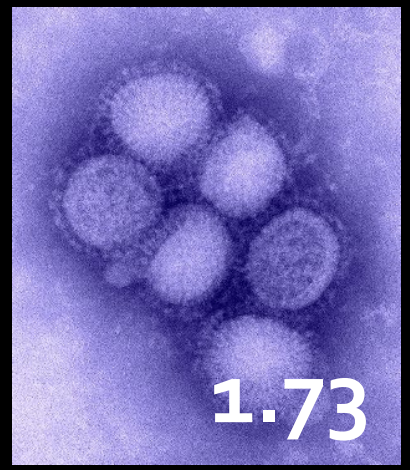
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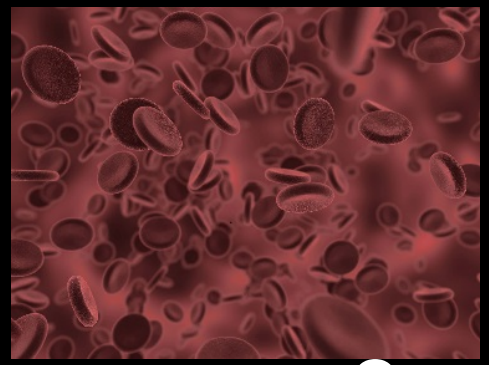

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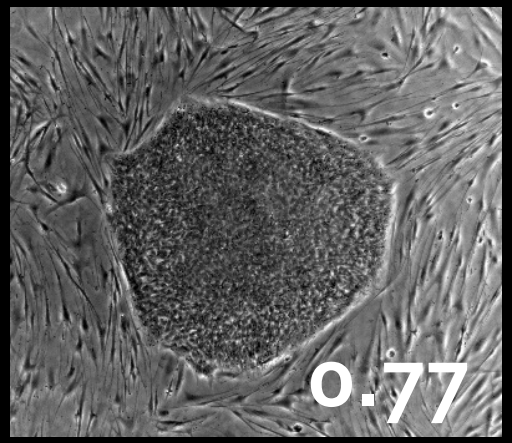

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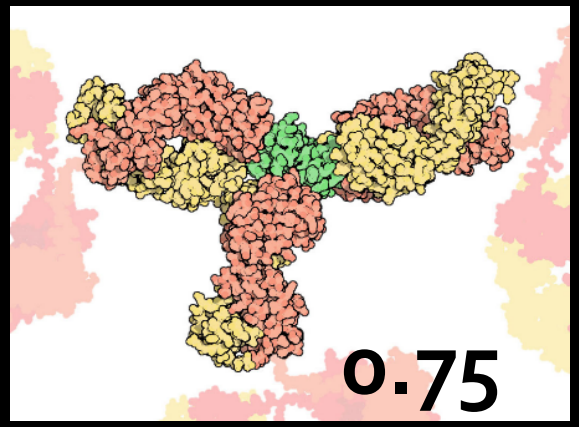

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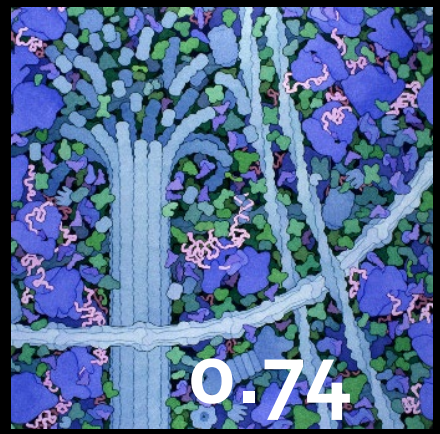

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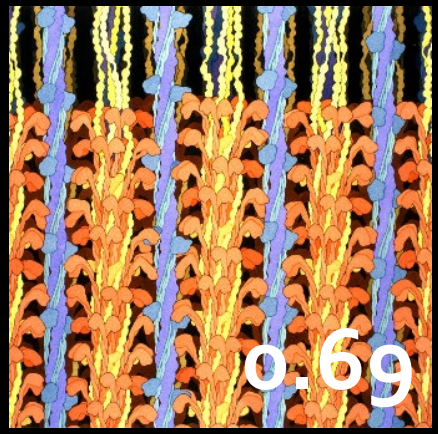

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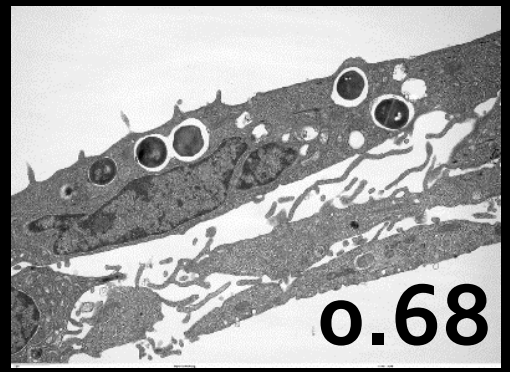

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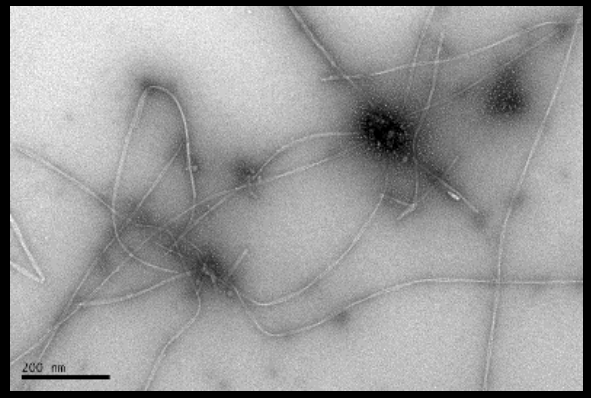

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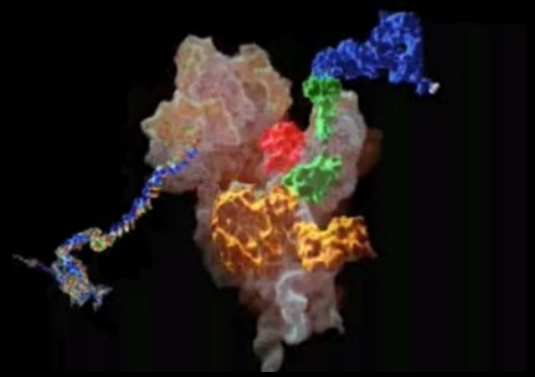

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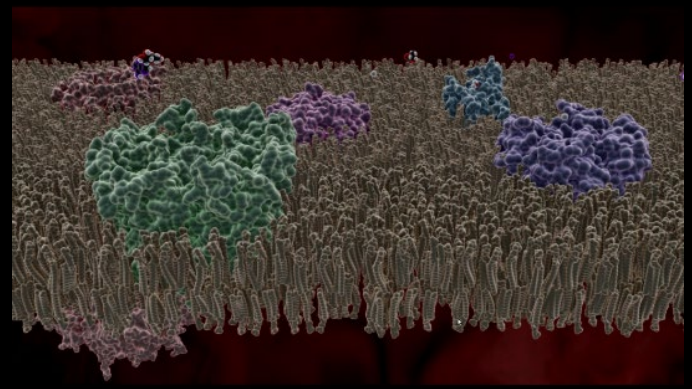

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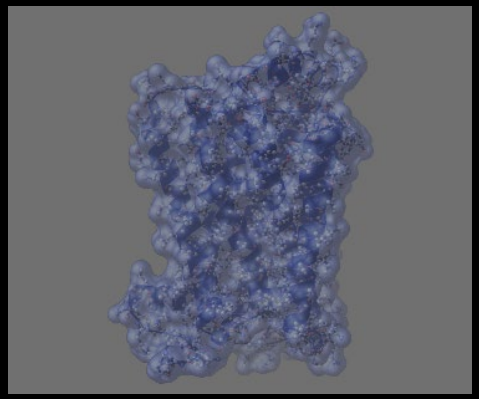

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# Consortium in a Design Process

- “It would be good to know a little more about how design decisions of the interactive tabletop were made. Were their design principles or theories of learning that informed specific decisions. For example, why use cards that can float on the table? Why have text on the back sides? Why categorize information in the way that you did? More to the point, what would an ideal user experience look like? What would visitors say, do, and learn, and how would the table support that?”

Reviewer comment in preparation of Höst et al., 2018

# Stakeholders and Challenges to Rise to?

- Education Researchers
- Media Technologists
- Scientists
- Producers
- Designers & Developers
- Guides
- Visitors
- Students

- One size fits all?
- Danger of trivializing?
- Different eyes on the problem?
- UX for different goals?
- Trade-offs?
- Technology trends?
- Technological lifetime?
- Longevity versus project time?

What other potential challenges might one have to face when designing a visualization environment for intended learning and communication?