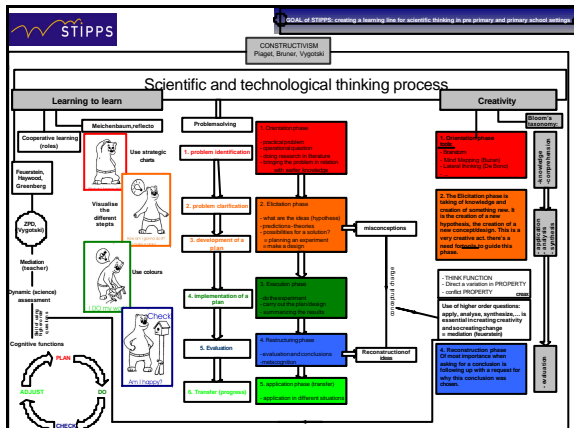


THE SCIENTIFIC THINKING PROCESS

State of the Art

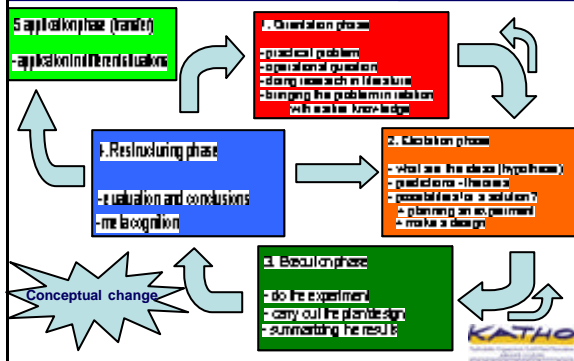
KATHO Tiel
Belgium

Nele Mestdagh
Kristof Van De Keere

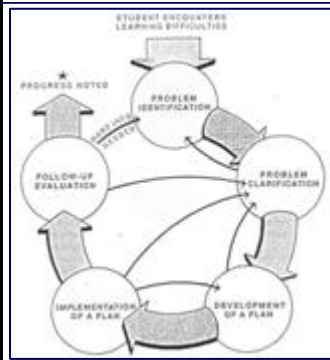


1. Scientific thinking process: our vision
2. Scientific thinking process – learning to learn
 - cooperative learning
 - blocks to learn
 - mediated learning
 - cognitive processes
3. Scientific thinking process - Creativity: an approach
4. Synthesis

The scientific and technological thinking process

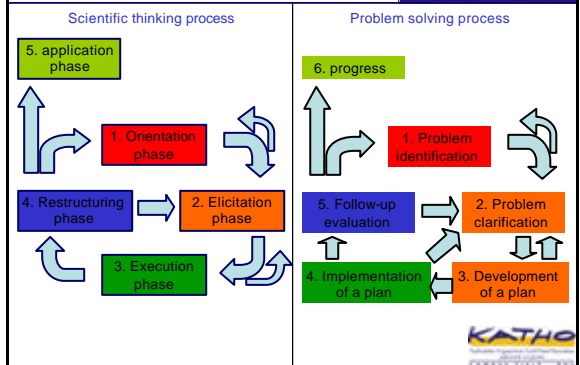


The Problem-Solving Cycle

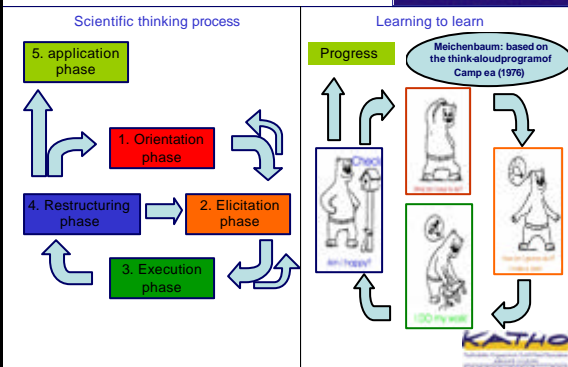


Samuels, M. (1994).
**Taking action in the classroom:
 Assessments
 and Program Planning for students with
 learning difficulties.**

Similarity between Scientific thinking and problem solving!



Similarity between Scientific thinking and learning to learn!



Cooperative learning

Herrenkohl, L. R., Sullivan-Palincsar, A., et al. (1999) Developing Scientific Communities in Classrooms: A Socio-cognitive Approach

Student Roles—Small Group Procedural Roles

Reporter 1	Distribution of lab notebooks Monitoring each member's record of the experiment
Reporter 2	Distribution of "scribe materials" Monitoring scribes' work on presentation materials
Scribe 1	Gather and bring supporting materials needed for reporting Get and maintain group materials Monitor appropriate use of materials
Scribe 2	Participate in designing and completing materials for reporters to use during reporting time Reads problem and Coordinates clean up
Scribe 3	Participate in designing and completing materials for reporters to use during reporting time Timekeeper and noise monitor* [Scribe 1] Participate in designing and completing materials for reporters to use during reporting time

Note: In cases where there are only four group members, Scribes 1 and 2 share the jobs usually assigned to Scribe 3.

Student Roles—Audience Roles

Predicting and Theorizing	Checking group's predictions and theories
Summarizing results	Checking group's summary of results
Relating predictions and theories	Checking group's discussion to results of the relationships among predictions, theories, and results

Factors Relating to the Learning Process



The learner is an active thinker (constructivism)

The teacher is a facilitator of learning
An effective teacher is viewed as

- A mediator
- One who is aware of the impact of personal beliefs on teaching
- A problem-solver who strives to understand the unique needs and characteristics of each students



Characteristics of Mediated Learning

Feuerstein



- **Intentionality:**
 - use of interaction to produce cognitive change
 - **what are we going to learn?**
- **Transcendence**
 - generalizable rules and principles are stressed
 - **where and when can we apply this again?**
- **Meaning & Purpose**
 - communicate the meaning and purpose for learning
 - **why?**
- **Communication of Competence**
 - communicate feelings of competence to the learner
 - specific feedback
- **Regulation of Behaviour**
 - assist students to control their behaviour in learning situations
 - encourage students to search for new goals, strategies to reach these goals



Mediational Teaching Style



- **Process Questioning**
 - Promote thinking about the process needed and the content
 - Continuous assessment of the student's understanding
- **Bridging**
 - encourage to think of other applications of the used strategies
 - assess if the student can generalize what he is learning
- **Challenging & requiring Justification**
 - challenge both correct and incorrect responses
 - provide effective feedback for learning
- **Emphasizing Rules & Strategies**
 - focus upon generalizable strategies
 - make strategies explicit



Cognitive Processes



- Cognitive processing (or functions) takes place in 3 phases (Feuerstein)
 1. Gathering of information in the input phase
 2. Processing of information in the elaboration phase
 3. Performance at the output phase



- Difficulties in a number of processes may interfere with the accurate gathering, processing and output of information



Cognitive processes



1. INPUT phase: gathering of information

Attention: use all senses to observe
Focus attention

Perception: planning and assembling data systematically
discriminate similarities and differences
based on critical features (precision)

Receptive Language: Use the right vocabulary

Considering two or more sources of Information simultaneously



Cognitive processes



2. ELABORATION phase: processing of information

Defining the problem: understanding of what is expected

Relevant and Irrelevant information: deciding which information is
important for solving a problem

Making Comparisons: compare how 2 things are the same or different

Logical Reasoning: cause and effect relations

Memory: having a broad mental field, summarize, abstract, ...

Visualization: the ability to mentally picture information (frame of reference)

Develop strategies to test hypotheses



Cognitive processes



3. OUTPUT phase: performance at the output phase

Planning: Inadequate adjustment of time and tempo

Expressive Language: Being able to put into words what is known

The need to be accurate: trial and error responding and not knowing
how to solve the problem
Thinking before doing

Blocking or Non-responding: knowing the answer, but unable to
demonstrate it because of fear of
being wrong

Visual-Motor coordination: transport of information



Learning to learn and scientific thinking Synthesis



During mediation (eg dynamic science assessment*), we
have to focus on these cognitive processes, in order to
produce cognitive change.

The scientific thinking process can be an effective tool to
work systematically on these cognitive processes.

...don't forget creativity

* Magnusson, J. M., Templin, M., Boyle, R. A.
(1997). Dynamic Science Assessment: A New
Approach for Investigating Conceptual Change.



What is creativity?

Creativity is shared imagination



What is creativity?

Creativity is shared imagination

- 'Imagination' as novel memory and individual or personal
- 'shared' in the sense that someone becomes part of it

Making someone aware of a novel, personal visualisation

- Creativity becomes innovative when a commercial application becomes apparent.
- If the creativity is not domain specific it becomes an invention

Are you creative?

<http://www.creax.com/csa/>

Take the water out
of the glass

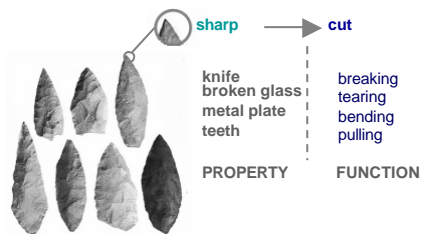
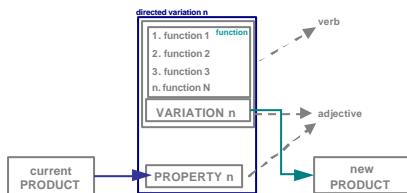
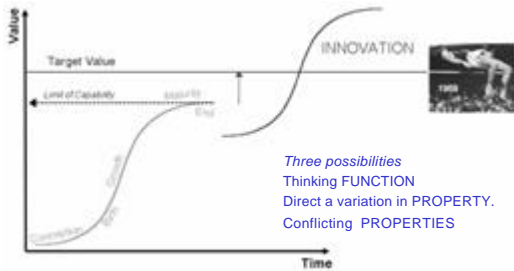


"Solutions change, functions stay the same"

Are you creative?

Acoustic Cavitation	Electroosmosis	Osmosis
Acoustic Vibrations	Electrophoresis	Pascal Law
Archimedes' Principle	Electrostatic Induction	Resonance
Bernoulli's Theorem	Ellipse	Shock Wave
Boiling	Evaporation	Spiral
Brush Constructions	Ferromagnetism	Super Thermal Conductivity
Capillary Condensation	Forced Oscillations	Superfluidity
Capillary Evaporation	Funnel Effect	Surface Tension
Capillary Pressure	Gravity	Thermal Expansion
Coanda Effect	Inertia	Thermocapillary Effect
Condensation	Ionic Exchange	Thermomechanical Effect
Coulomb's Law	Jet Flow	Ultrasonic Capillary Effect
Deformation	Lorentz Force	Ultrasonic Vibrations
Electrocapillary Effect	Magnetostriction	Use of foam
	Mechanocaloric Effect	Wetting


"Solutions change, functions stay the same"






Tools on creativity and scientific thinking


1. Orientation phase



Alex Osborn Buffalo
Brainstorming 1954
www.CEF-CPSI.org



Tony Buzan
Mind Mapping 1968
www.mind-map.com



Edward De Bono
Lateral Thinking 1974
www.edwarddebono.com

2. The Elicitation phase

Taking of knowledge and creation of something new!
Creation of a new hypothesis
a new concept/design

➔

- Think FUNCTION
- Direct a variation in PROPERTY
- Conflict PROPERTY

KATHO

Cognitive processes and scientific thinking Synthesis

Elements	Attention	Perception	Receptive language	Considering 2 or more sources
Preschool 2½y-3y	Visualise the different steps of the scientific thinking process. Through the process of scientific thinking one can work on specific cognitive processes by using a mediational teaching style. Specific cognitive processes can be linked to specific stages in the process of scientific thinking. Developmental Demands on the cognitive processes (learning line) Use creativity tools to go further than the limit of capability!			
4y- 5y				
Primary school 6y- 7y				
8y- 9y				
10y-11y				

KATHO

