

## Process-Oriented Guided-Inquiry Learning



Students learn better when they are -

- Actively engaged and thinking in the classroom and laboratory.
- Drawing conclusions by analyzing data or models and discussing ideas.
- Working together in self-managed teams to understand concepts and solve problems.
- Reflecting on what they have learned and how to improve.
- Interacting with an instructor as a facilitator of learning.

POGIL provides a research-based structure and methodology for changing the way you teach. It is a student-centered method of instruction that provides opportunities to teach both discipline content and essential learning- process skills simultaneously.

The NSF-supported POGIL National Dissemination Project is directed at improving student learning by facilitating the use of process-oriented guided- inquiry curriculum materials and pedagogies.





# A Research-Based Cognitive Model Supporting POGIL

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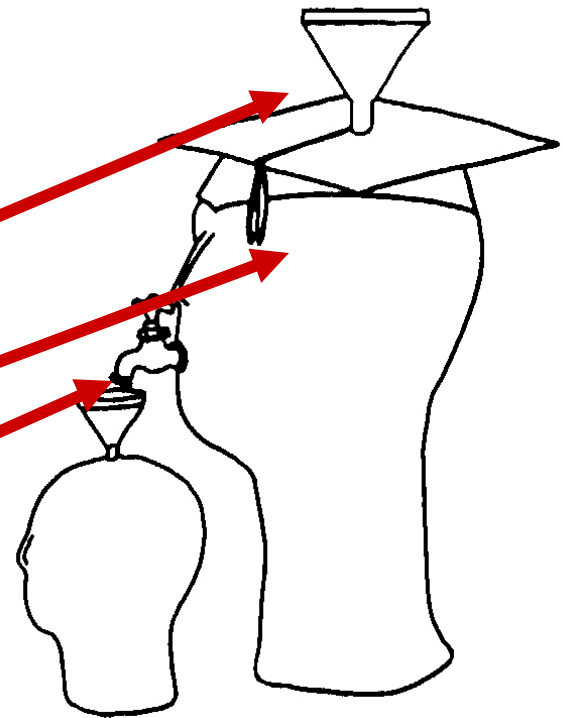
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# A cognitive model is

- a representation of mental processes.
- For example, the sage-on-the-stage model for learning.
  - Input
  - Storage
  - Output



# A cognitive model guides

- development of curriculum materials.
- implementation of teaching strategies that enhance conceptual understanding and problem solving.
- design of assessment and evaluation.
- research on learning and teaching.

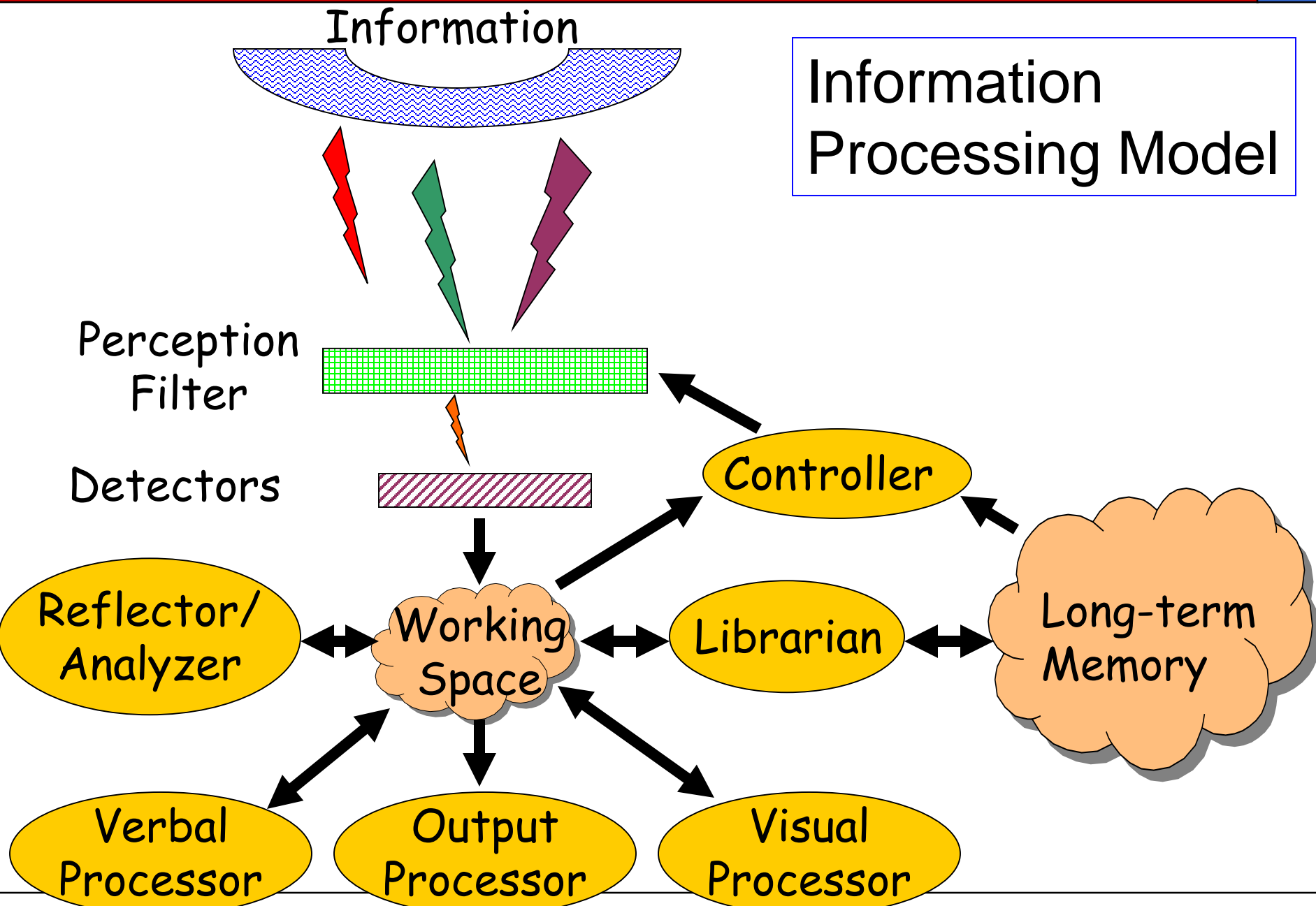
A cognitive model can be derived from

- research in the cognitive sciences.
- the continuum of changes that occur as novices develop and become experts in a discipline.
- experimental data testing the validity of proposed cognitive models.

## Origins of the proposed model.

- Johnstone's information processing model.
- Novice – expert comparisons.
- Research on visualizing and connecting macroscopic, particulate, and symbolic representations.

# Information Processing Model



## POGIL is based on research: people learn by -

- ❑ Constructing their own understanding and knowledge in a process involving prior knowledge, experiences, skills, preconceptions, attitudes, and beliefs.
- ❑ Following a learning cycle of exploration, concept formation, and application.
  - ❑ Perception Filter & Controller decides what gets through.
  - ❑ Librarian decides how to link new knowledge with existing knowledge and what gets retrieved.
  - ❑ → Guided Inquiry exercises these units and forces them to make sense of new knowledge.



POGIL is based on research: people learn by -

- ❑ Discussing and interacting with others.
  - ❑ Verbal Processor helps the Librarian.
  - ❑ → Learning teams provide opportunities to exchange ideas and confront misconceptions.
- ❑ Reflecting on their progress.
- ❑ Assessing their performance.
  - ❑ Reflector carries out these functions and improves the performance of the Librarian and Perception Filter system.
  - ❑ → Reflector's Report requires that the Reflector be utilized.

POGIL is based on research: people learn by -

- ❑ Visualizing concepts in multiple representations, for chemistry macroscopic, nanoscopic, and symbolic.
  - ❑ Visual Processor & Analyzer help the Librarian
  - ❑ → Analyze models in different representations, change representations, and come to conclusions
- ❑ Interconnecting conceptual and procedural knowledge in a hierarchical structure.
  - ❑ Librarian decides how to organize knowledge in long term memory.
  - ❑ → Learning Teams & Integrative Activities

# Use the Verbal and Visual Processors

- Explaining to others
- Drawing pictures and diagrams
- Reorganizing in lists and tables
  
- Helps the librarian store and retrieve knowledge effectively and efficiently

# Use the Reflector / Analyzer to strengthen brain processes.

- Think about what you are doing well and how you can improve.
- Such thoughts actually change the way the brain works.

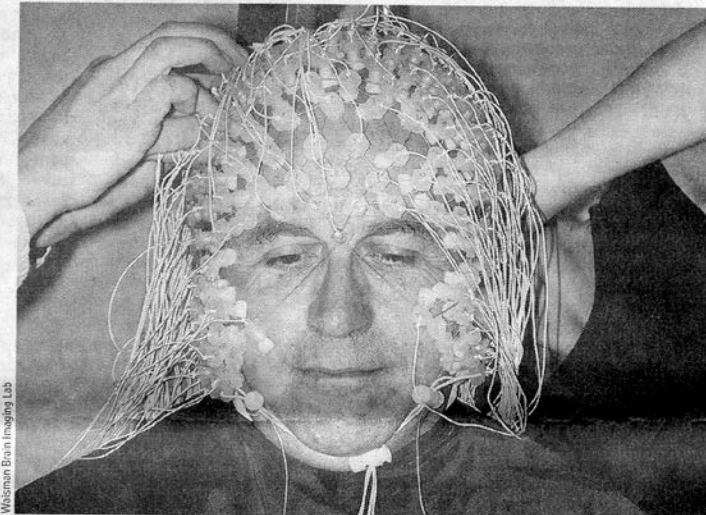
## *How Thoughts Can Change the Brain*

*Continued from the prior page*

unteers then received paroxetine (the generic name of the antidepressant Paxil), while others underwent 15 to 20 sessions of cognitive-behavior therapy, learning not to catastrophize. That is, they were taught to break their habit of interpreting every little setback as a calamity, as when they conclude from a lousy date that no one will ever love them.

All the patients' depression lifted, regardless of whether their brains were infused with a powerful drug or with a different way of thinking. Yet the only "drugs" that the cognitive-therapy group received were their own thoughts.

The scientists scanned their patients' brains again, expecting that the changes would be the same no matter which treatment they received, as Dr. Mayberg had found in her placebo study. But no. "We were totally dead wrong," she says. Cognitive-behavior therapy muted overactivity in the frontal cortex, the seat of reasoning, logic, analysis and higher thought. The antidepressant raised activity there. Cognitive-behavior therapy raised activity in the limbic system, the brain's emotion center. The



Walshman Brain Imaging Lab

Matthieu Ricard, a Buddhist monk, undergoing an EEG during a study of compassion meditation

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## So in a POGIL Classroom –



- ❑ Students work in self-managed teams
- ❑ on specially designed guided-inquiry activities
- ❑ to develop learning process skills in key areas
- ❑ and master course content
- ❑ with an instructor who is a coach or facilitator not dispenser of information.

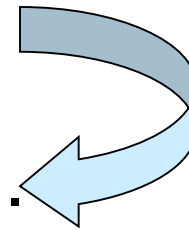


# Designing POGIL Activities

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# Stages of a POGIL Activity

- Orientation
  - Motivation, cognitive hooks, overview, prerequisites.
- Exploration
  - Generate a need to know.
- Concept formation or invention.
- Application
  - Exercises (familiar contexts). Problems (new contexts).
- Closure
  - Reflection on learning. Assessment of performance.



Key Questions

# Activity Types

- Exploration of a model.
- Writing assignment.
- Problem-solving session.
- Student teaching.
- Individual project or paper.
- Research project.
- Group discussion.
- Debate.
- Student presentation.
- Interviewing.
- Self-assessment.
- Peer-assessment.
- Reflection on learning.
- Team learning.
- Use of technology.
- Problem-based learning.
- Case studies.



# Models to Explore

- Figure.
- Graph.
- Table of data.
- Written relationships.
- A methodology.
- Discussion.
- Demonstration.
- Examples.
- Laboratory activity.
- Student lecture notes.
- Student reading notes.
- Interactive computer simulation.
- Animation or film clip.
- Lecture or mini-lecture.
- Reading assignment.

# Key Questions Guide Exploration

- Directed - Exploratory
  - Students process and recall information. Answer found directly in the model, information, or resources.
- Convergent – Concept Formation
  - Students make connections and reach conclusions. Answer not directly available, requires analysis and synthesis.
- Divergent
  - Students expand on their new knowledge by pondering, further exploring, and generalizing.

# Examples of Key Questions

- What is the weakest type of intermolecular interaction identified in the model?
- What insight has your team gained from the model about why some materials are gases and others are liquids or solids at room temperature?
- What are other examples from your own experience of each type of intermolecular interaction?

# Exercises and Problems

- Determine how much energy it takes to heat 100 g of water from 22 °C to 80 °C. The specific heat capacity of water is 4.18 J/g °C.
- Burning propane ( $\text{C}_3\text{H}_8$ ) produces gaseous carbon dioxide and water. The enthalpy of combustion is -682 kJ/mole. Determine how much water you can heat from room temperature (22 °C) to boiling (100 °C) with 1 pound of propane. The specific heat capacity of water is 4.18 J/g °C.

## Real-World or Level 2 Problem

- You are camping at your cabin in the woods. You have  $\frac{1}{4}$  pound of propane remaining in the tank. Will you be able to take a hot bath tonight?

# Instructional Design Methodology

- Setup
  - Organize by topic and subtopic.
  - Identify learning objectives.
  - Identify success criteria.
  - Put together an appropriate activity.

# Components of an Activity

- Establish a need to learn.
  - Why is this activity important.
- Make a connection to the research/technology frontier.
- Make a connection to prior understandings and knowledge.
  - What do you know about ...?
  - What do you predict for ...?
  - How do you explain ...?
  - Use the literature on misconceptions for ideas.

- Provide a guided inquiry.
  - Use key questions to explore a model.
- Provide exercises.
  - Simple or familiar applications.
- Check understanding.
  - Ask one or two concept questions in a *Got It!* section.
- Provide problems.
  - Complex applications.
  - Applications in new contexts.



- Support problem solving.
  - Students work together.
  - Model and require the use of heuristics.
    - Understand & analyze, plan, execute, and validate & interpret.
  - Model and require the use metacognition for both examples & problems.
    - Connect both conceptual knowledge and procedural knowledge to the solution.
    - What was done?
    - Why was it done?

- Integrate the new knowledge with prior knowledge in a *Making Connections* section.
- Reflect on how to apply the new knowledge in new situations in a *What If?* section.
- Reflect on what was learned.
- Assess how the learning process can be improved.
- Provide readings, additional exercises, examples, and problems for reinforcement and practice.

# Resources for Activities

- [www.pogil.org](http://www.pogil.org)
- [www.pcrest.com](http://www.pcrest.com)
- [www.pltl.org](http://www.pltl.org)
- <http://Bioquest.org>
- Published materials, samples available.
- Use learning objects for exploration.
  - [www.merlot.org](http://www.merlot.org)
  - NSDL projects
  - Other internet sites