Teaching Complexity In Virtual Space

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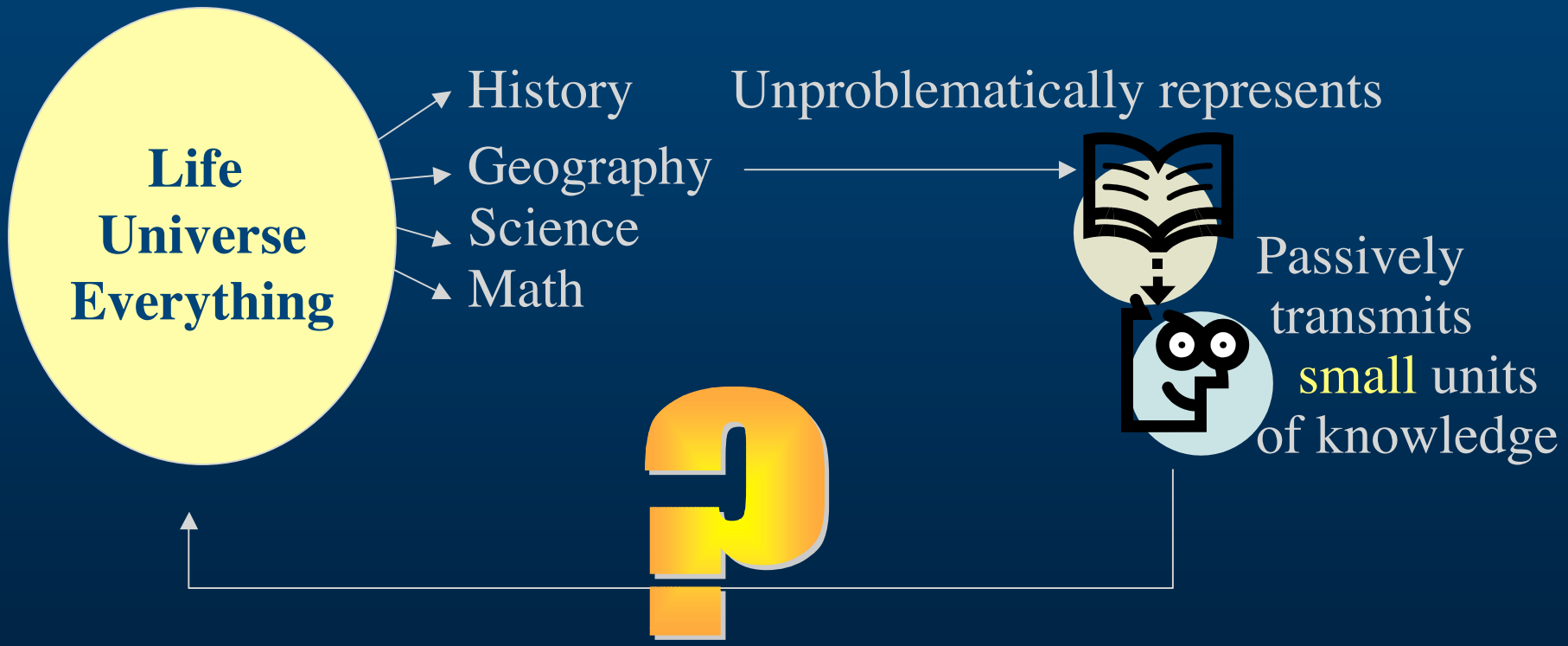
Agenda

- Learning Theory
- Complex Domains
- HITL Contributions
  - Virtual Coach
  - Virtual Puget Sound
  - Protein Book
- Future Directions

Tradition

De-contextualizes knowledge

Separates into disciplines



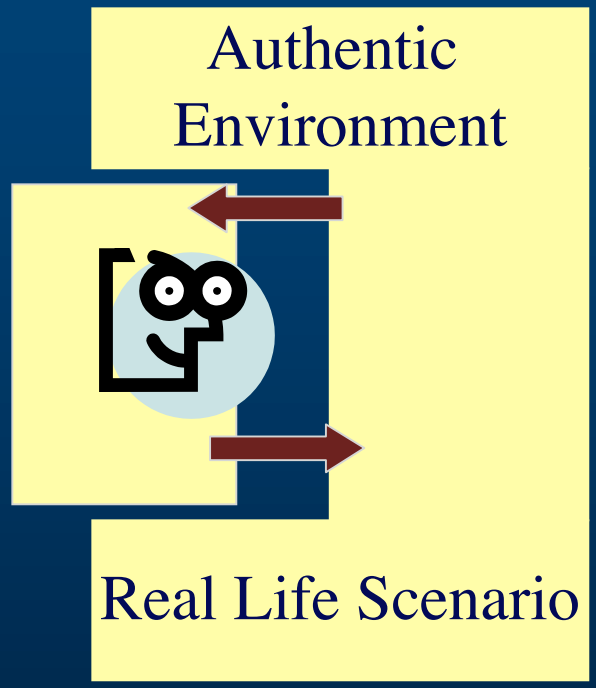
Results: Inability to apply "learning" to relevant situations.
It seems efficient, but if it is not effective, is it *really* efficient?

Reversing Tradition

- Make Unit of Knowledge a “System”
- Make Learning require Activity
- Make Knowledge Problematic
- Cross discipline boundaries (as needed)
- Provide Context (system or context of system)
- Situate in a “real world” scenario

Fast Forward

- Situated Contextualized Learning
  - Embedded in the environment
  - Physical Embodiment
- Adaptation
  - Student and environment:
    - coupled system
    - self-organizing
    - dynamically evolving



What would you learn if you could…

- Control time → speed it up or slow it down
- Control scale → expand or shrink objects & space
- Go anywhere → without effort
- Do any experiment → without harming anything
- Take any risk → without fear of failure
- Ignore cost → without fear of going broke or losing your job?

Strategic Thinking

For Decisions:

- Evaluate Long Term Consequences

For Actions:

- Consider 2nd order consequences

For the Future:

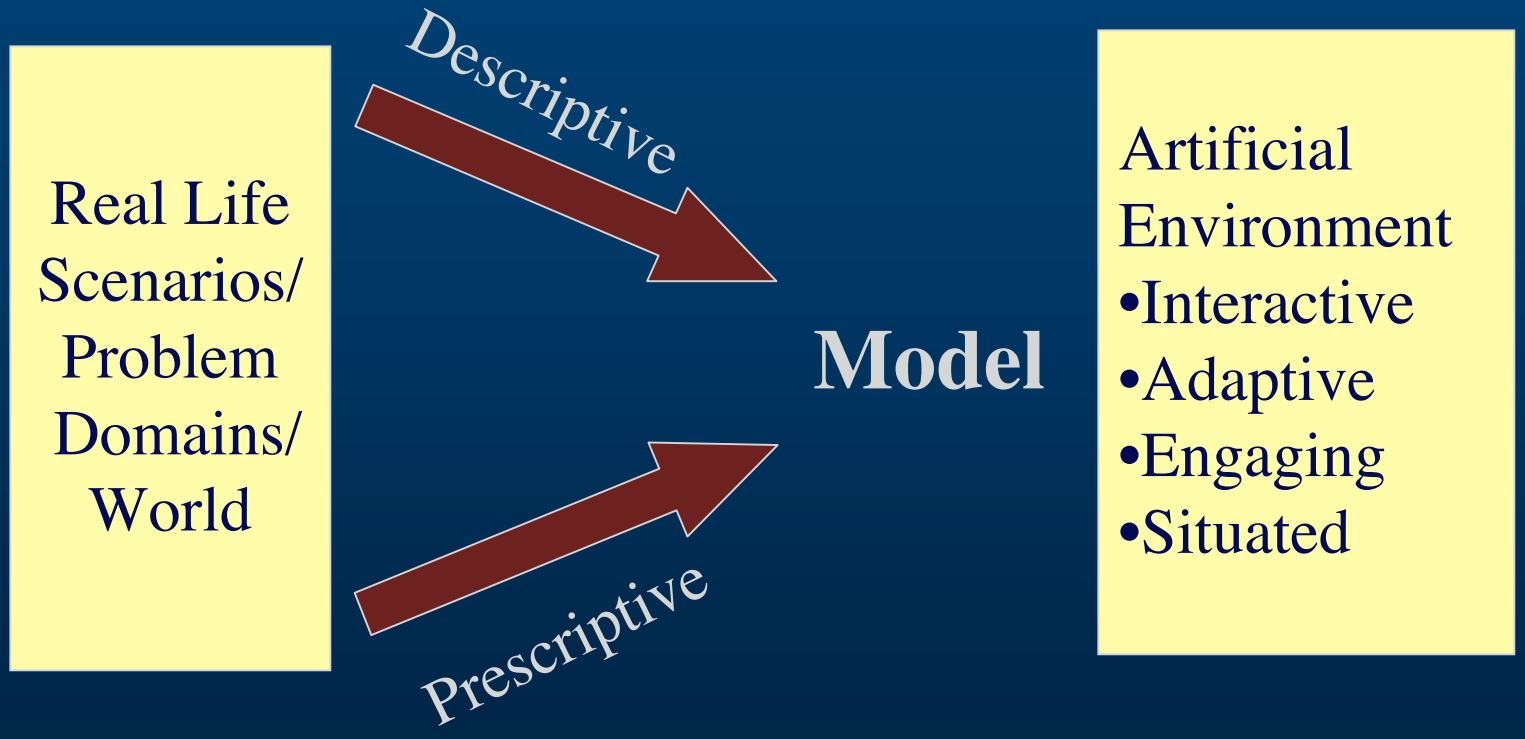
- Look for early signs of problems

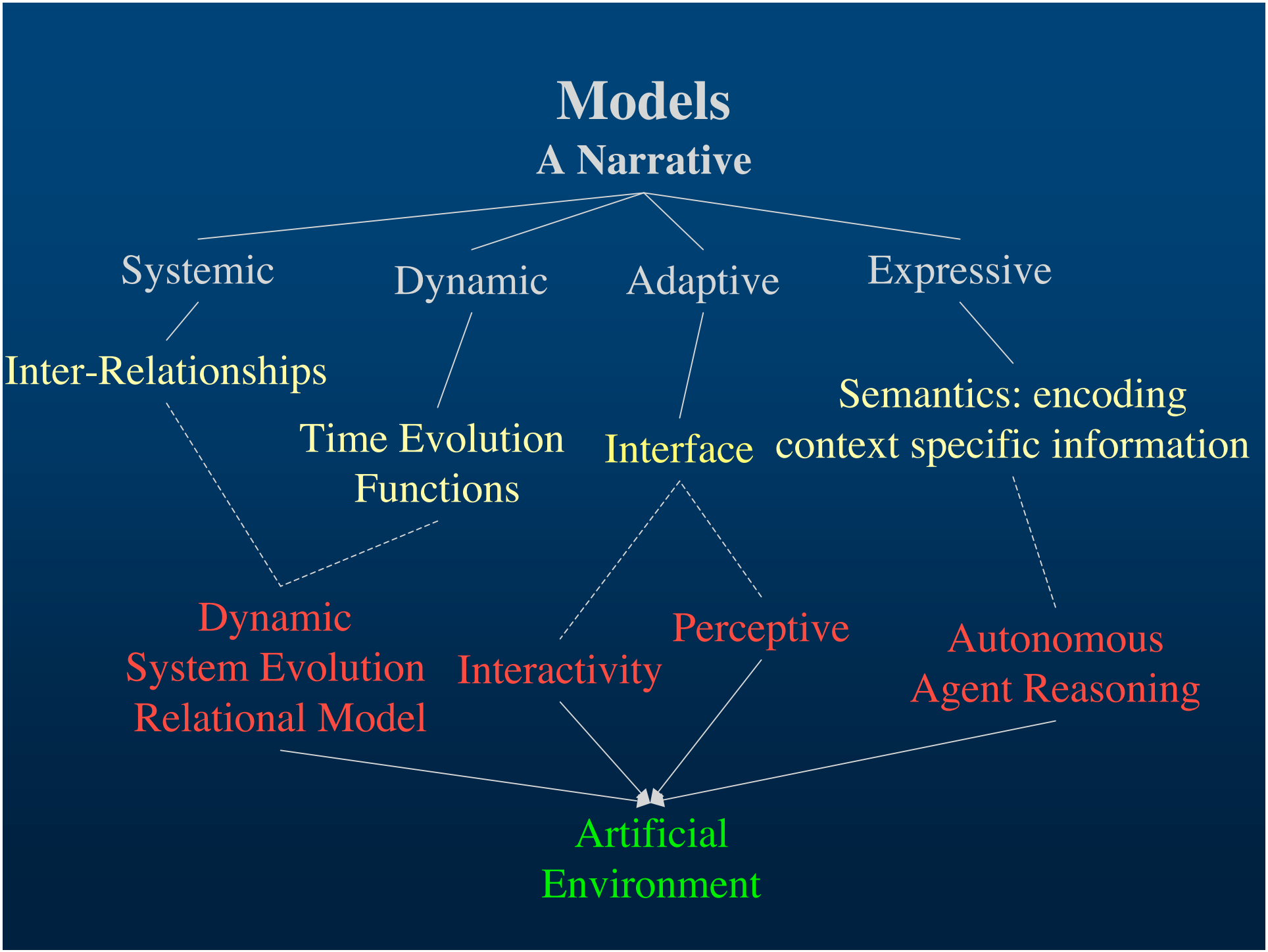
Metacognitive Skills

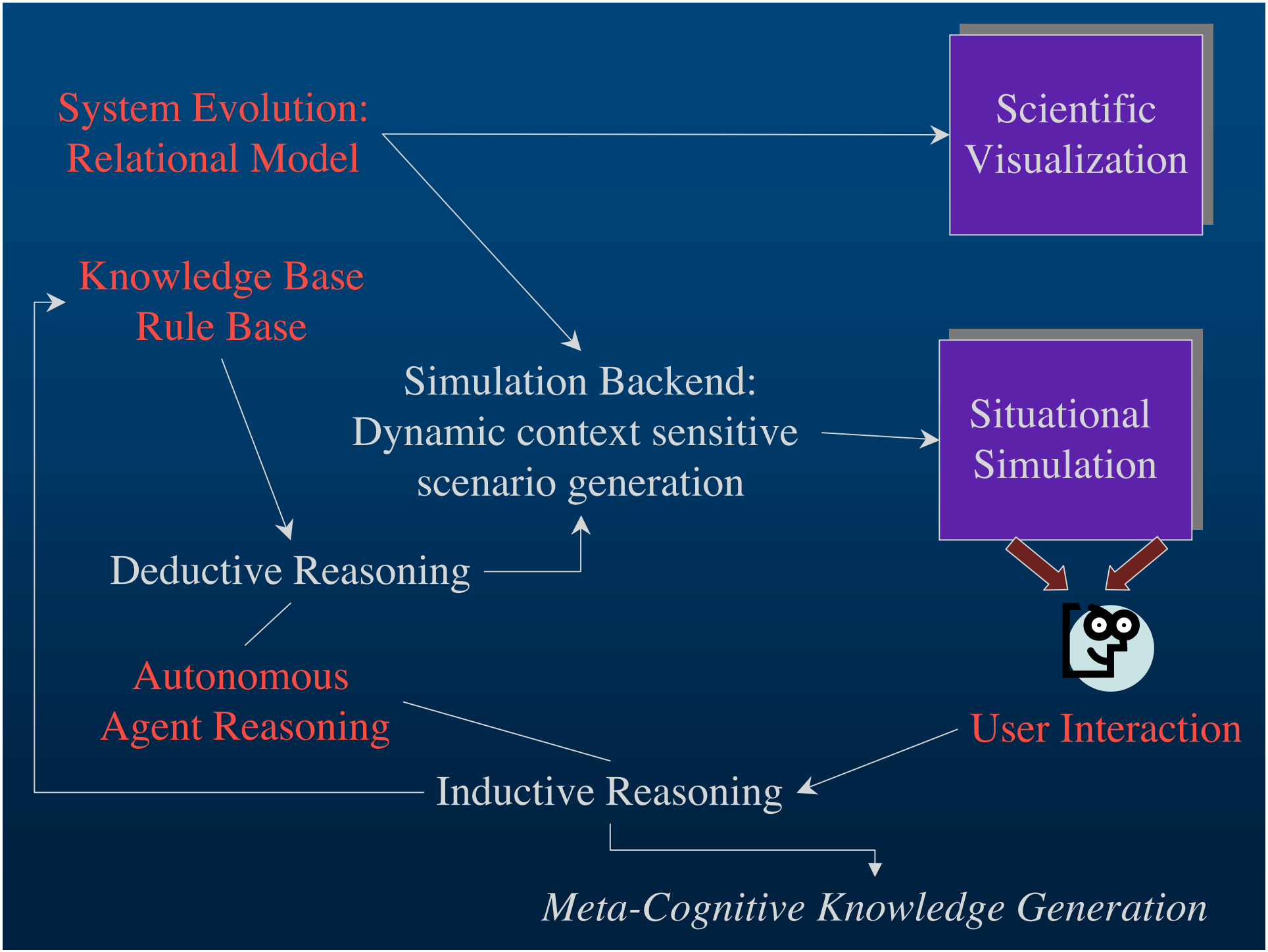
For Complex Systems:

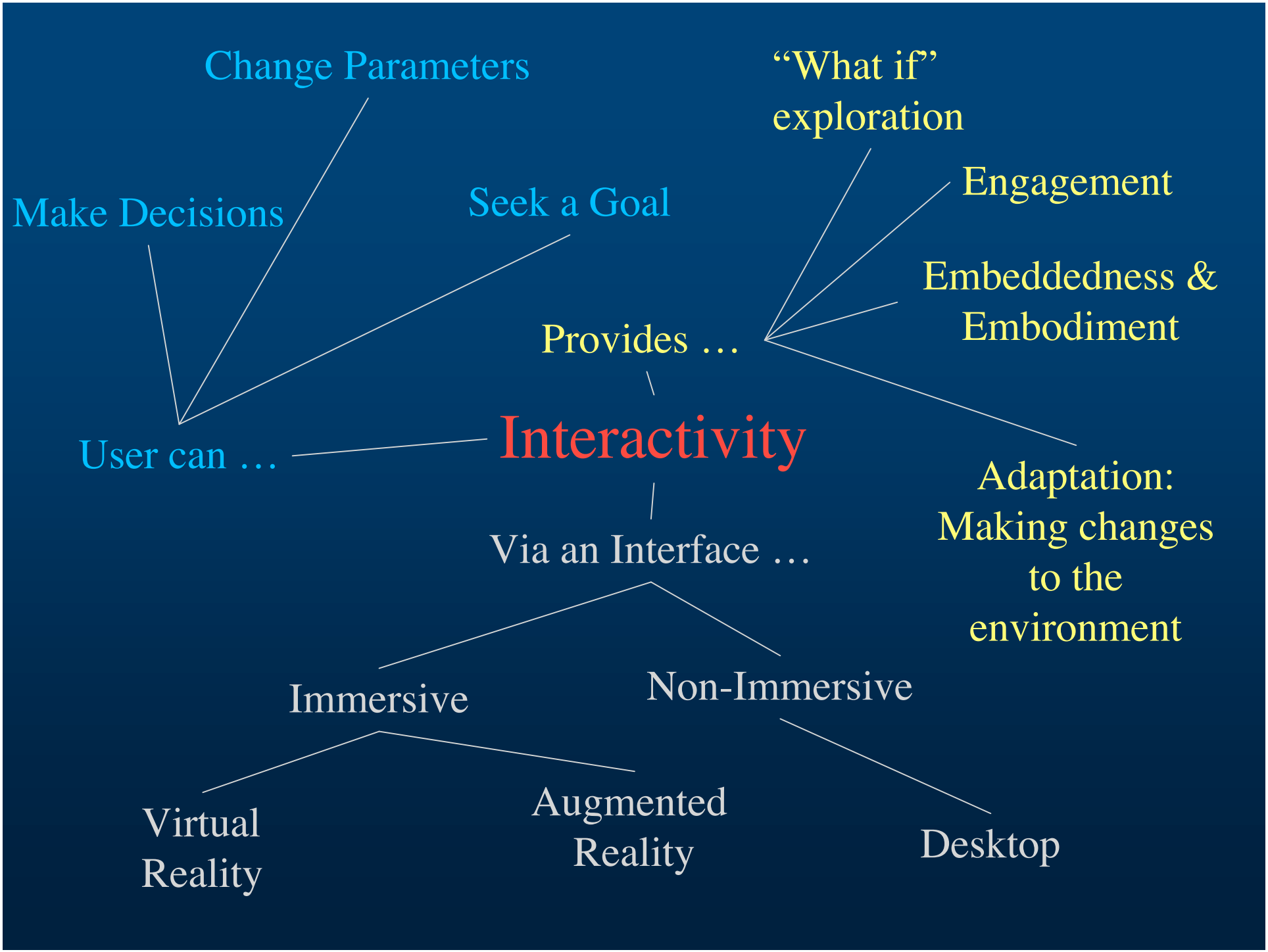
- See the whole and the parts
- Look for relationships and interdependencies
- Look for multiple causes and effects
- Use circular or closed-loop thinking

Challenge


Real Life Scenarios/ Problem Domains/ World
Descriptive
Prescriptive
Model
Artificial Environment
•Interactive
•Adaptive
•Engaging
•Situated


Models
A Narrative
Systemic
Dynamic
Adaptive
Expressive
Inter-Relationships
Time Evolution Functions
Interface
Semantics: encoding context specific information
Dynamic System Evolution Relational Model
Interactivity
Perceptive
Autonomous Agent Reasoning
Artificial Environment


System Evolution:
Relational Model
Scientific
Visualization
Knowledge Base
Rule Base
Simulation Backend:
Dynamic context sensitive
scenario generation
Situational
Simulation
Deductive Reasoning
Autonomous
Agent Reasoning
User Interaction
Inductive Reasoning
Meta-Cognitive Knowledge Generation


Change Parameters
"What if" exploration
Make Decisions
Seek a Goal
Engagement
Embeddedness & Embodiment
Provides …
User can …
Interactivity
Adaptation: Making changes to the environment
Via an Interface …
Immersive
Non-Immersive
Virtual Reality
Augmented Reality
Desktop

Complex Domains

Macro

Virtual Puget Sound

- VR Environments
- Scientific Visualization
- Interactive

Micro

Magic Book

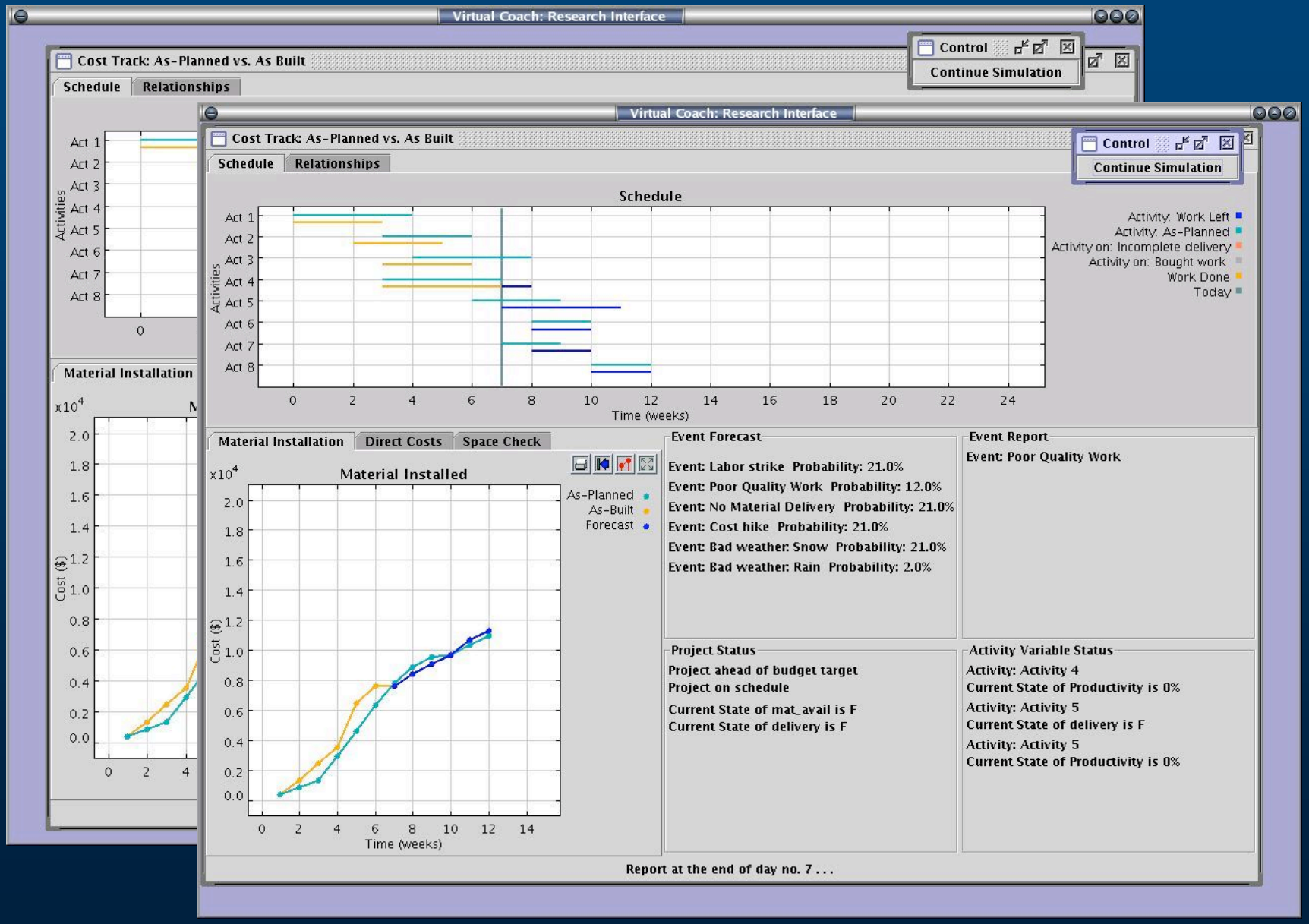
- AR Environments
- Scientific Visualization
- Interactive

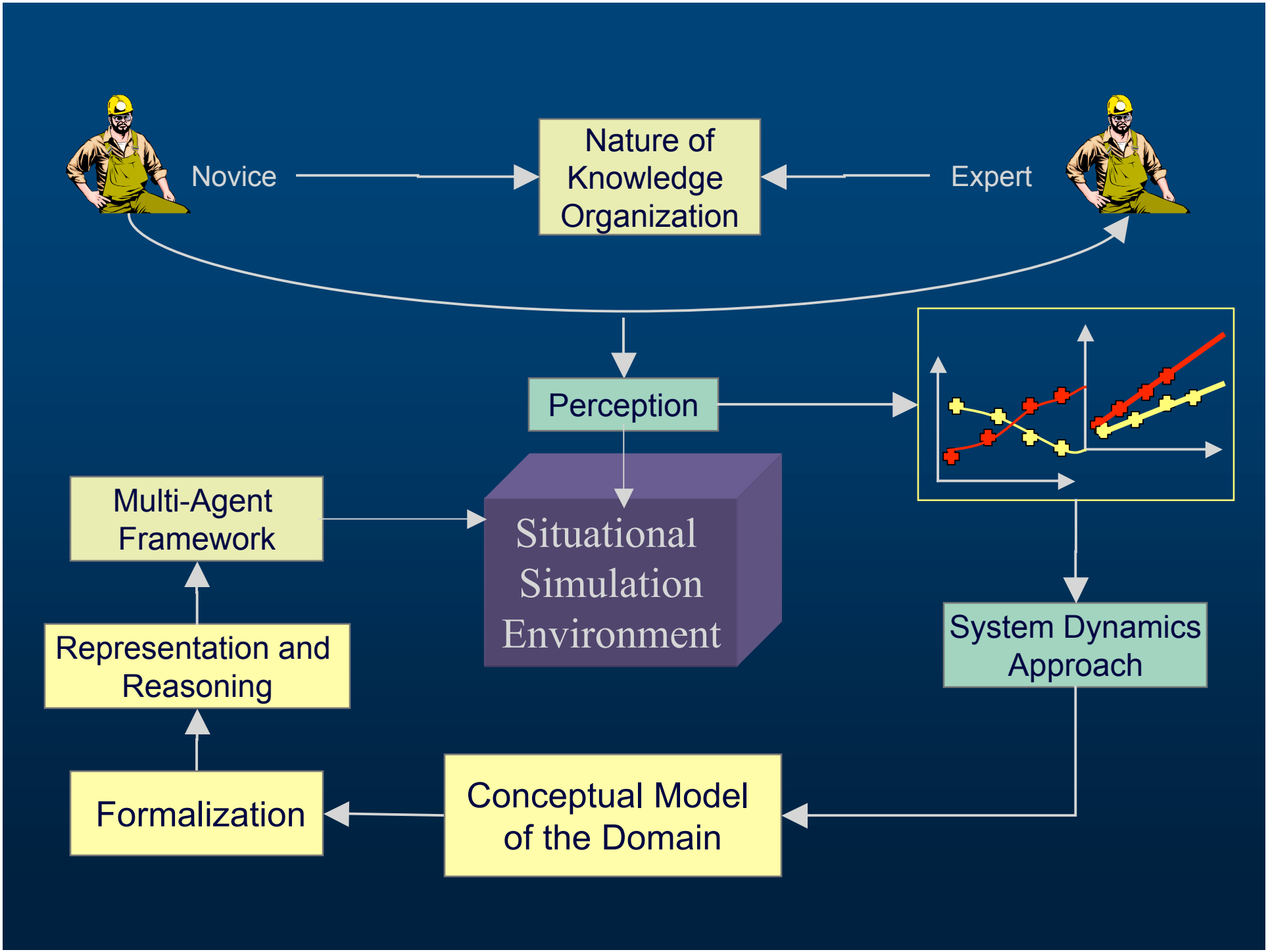
Socio

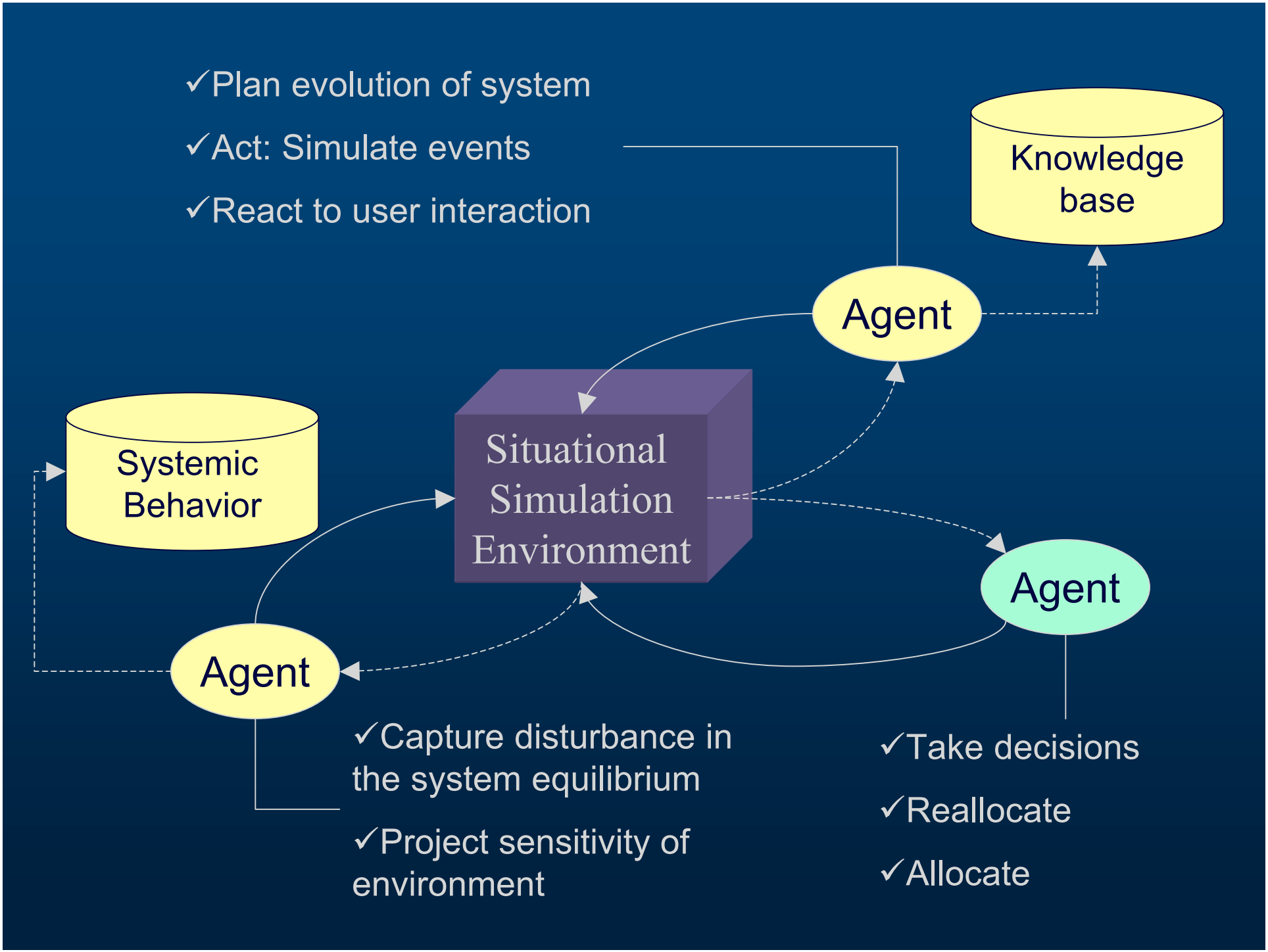
Construction Management

- Desktop Situational Simulations
- Autonomous Agent Driven (Deductive Reasoning)
- System Dynamic Model
- Interactive

For Construction Managers



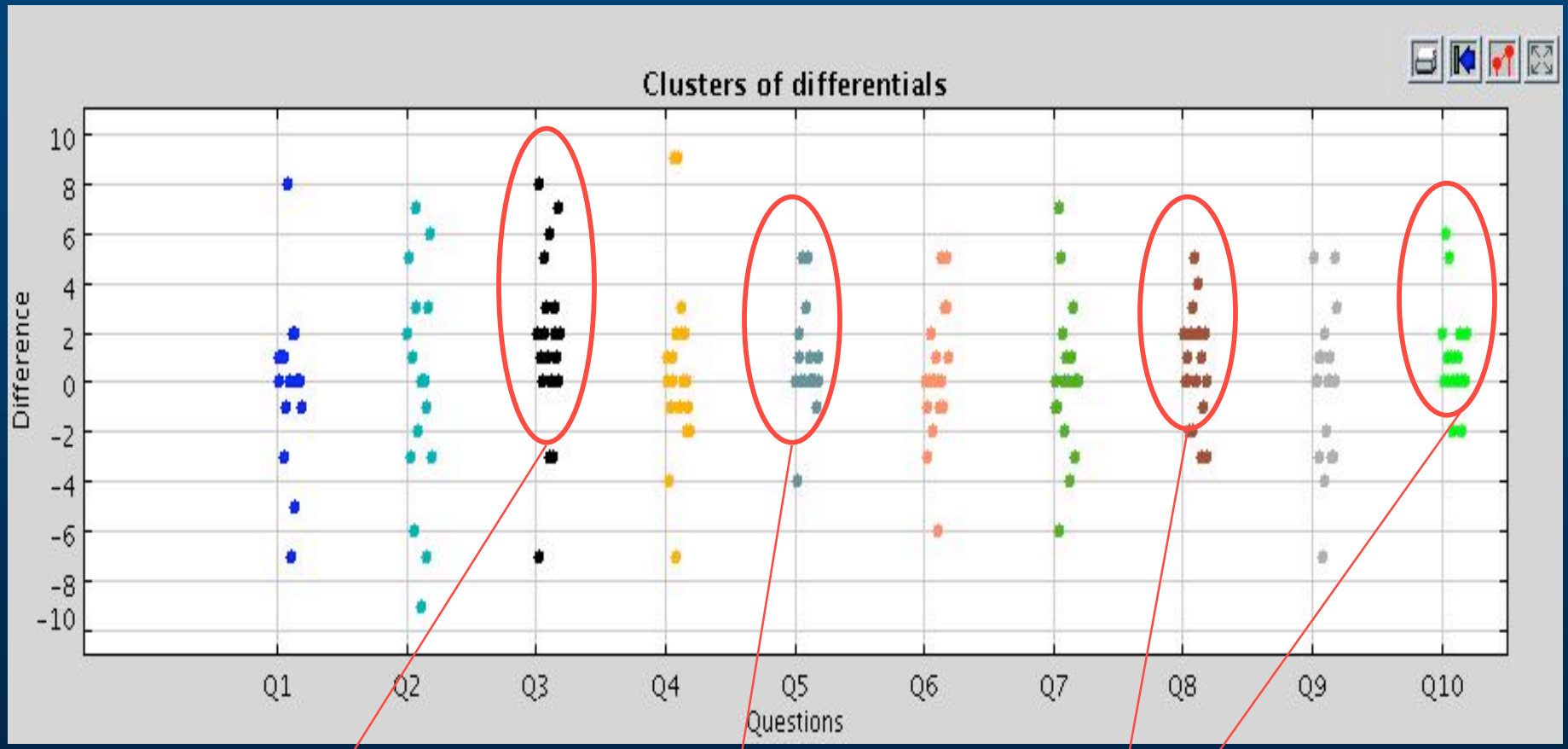

Novice
Nature of Knowledge Organization
Expert
Perception
Multi-Agent Framework
Situational Simulation Environment
System Dynamics Approach
Representation and Reasoning
Formalization
Conceptual Model of the Domain


✓Plan evolution of system
✓Act: Simulate events
✓React to user interaction
Knowledge base
Agent
Systemic Behavior
Situational Simulation Environment
Agent
Agent
✓Capture disturbance in the system equilibrium
✓Project sensitivity of environment
✓Take decisions
✓Reallocate
✓Allocate

Testing

- Tested with 19 Senior level CM students: Pre-test/ Post-test protocol
- Claim I: The environment is useful for training about the CM domain
- Claim II: Learning in the CM domain is based on an understanding of *Precedence and Resource Constraint Satisfaction*

Results

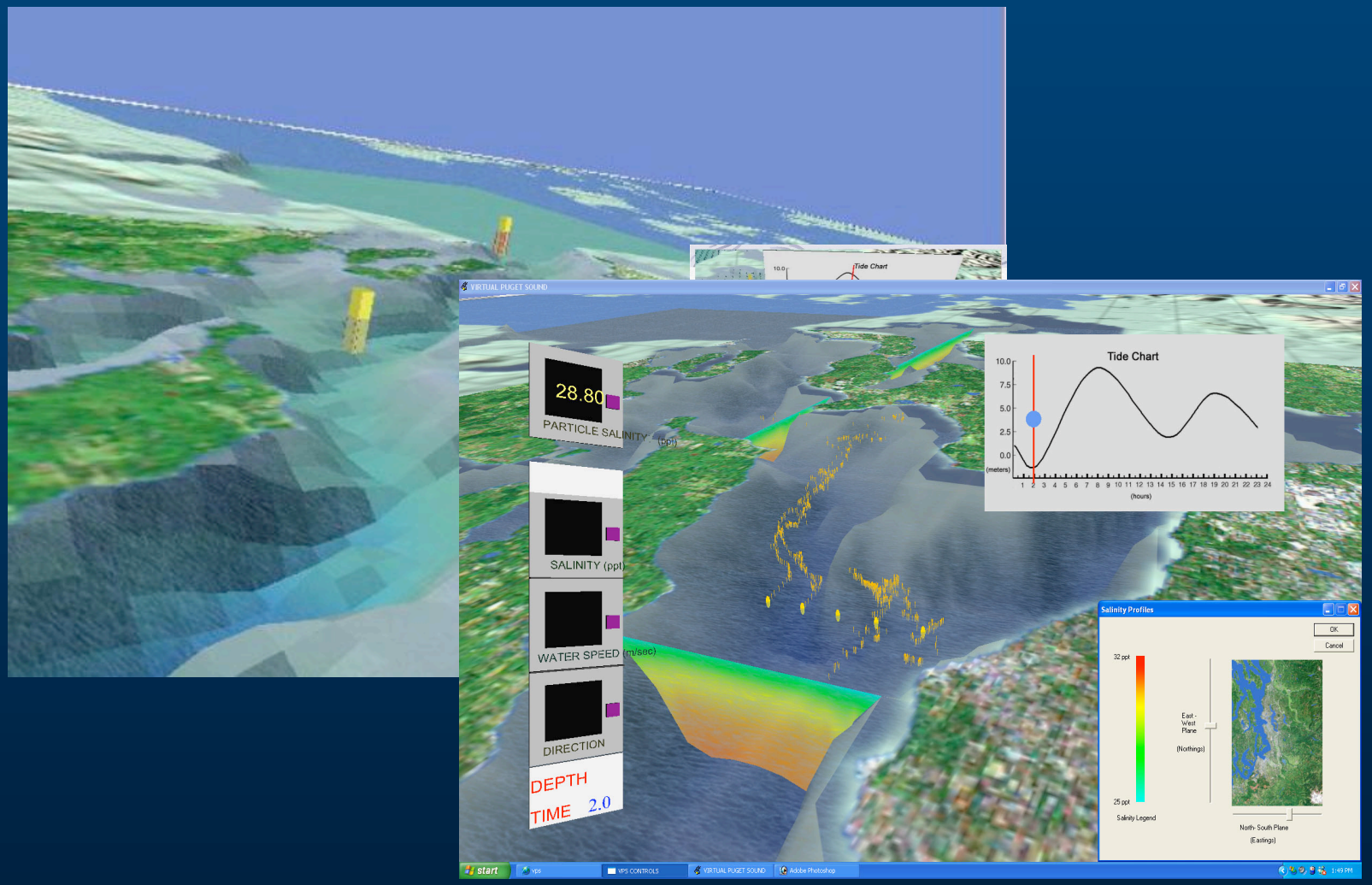


Resource Constraint Satisfaction

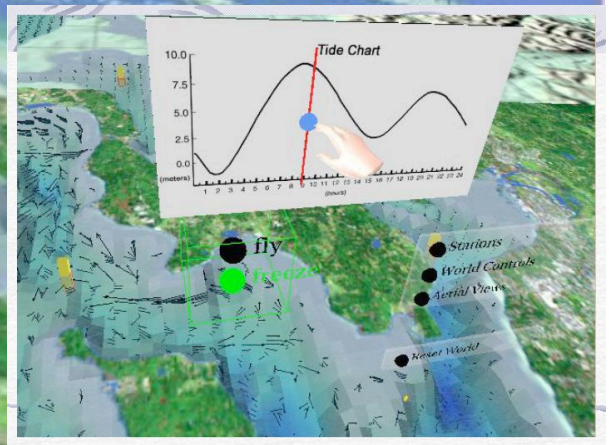
Temporal Constraint Satisfaction

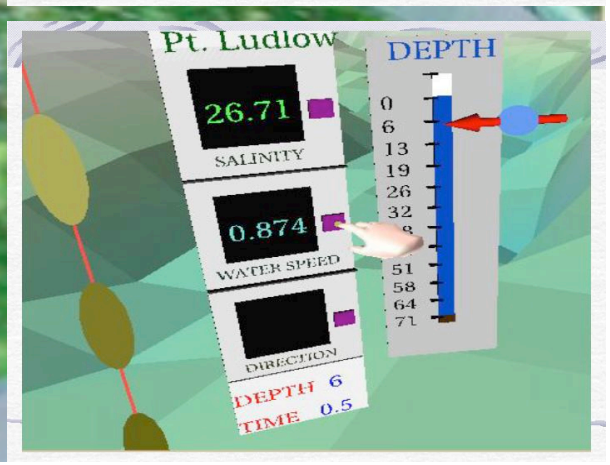
Event Scheduling / Event Premonition

The Virtual Puget Sound

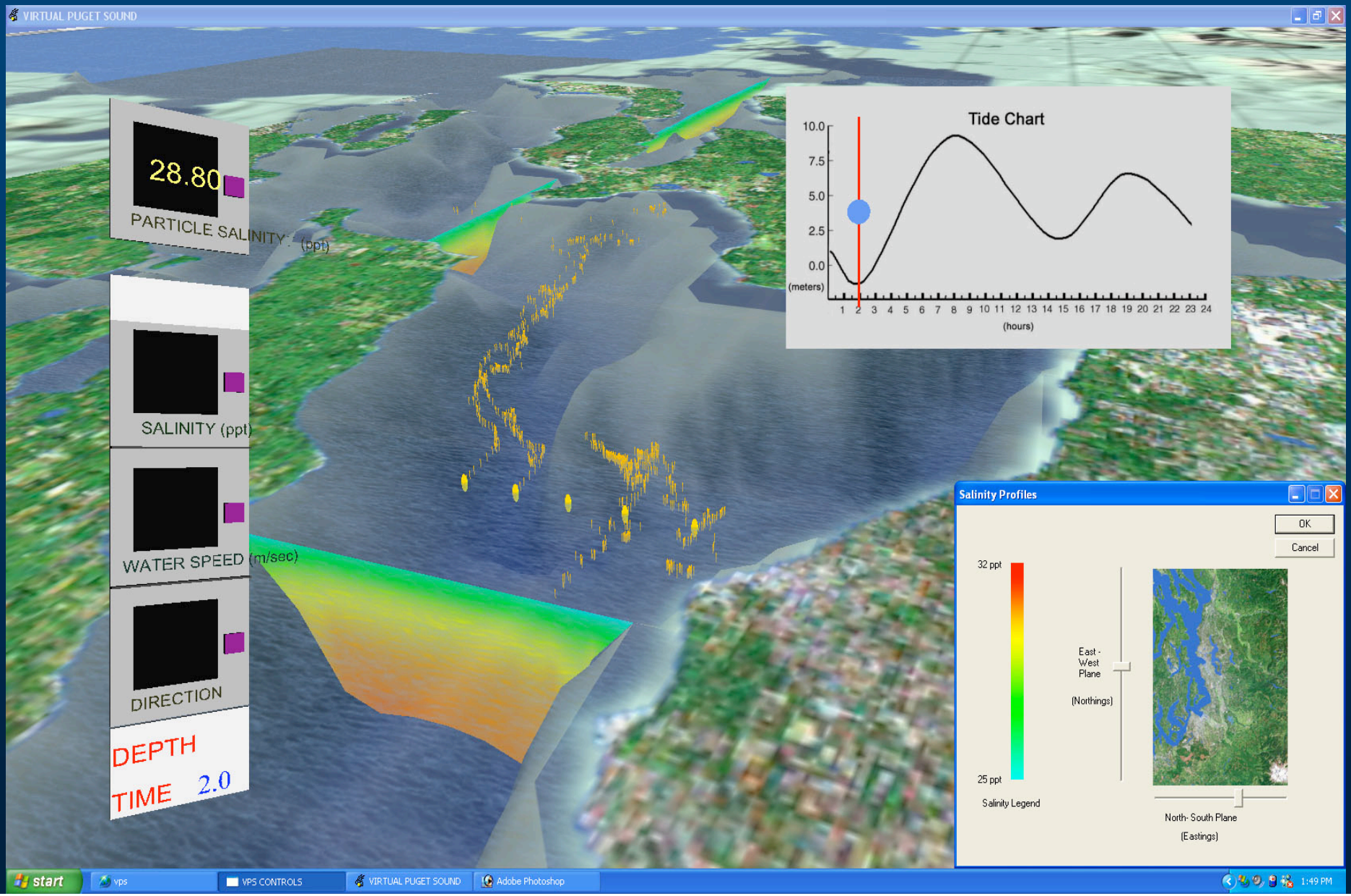


Virtual Puget Sound –
Virtual Reality

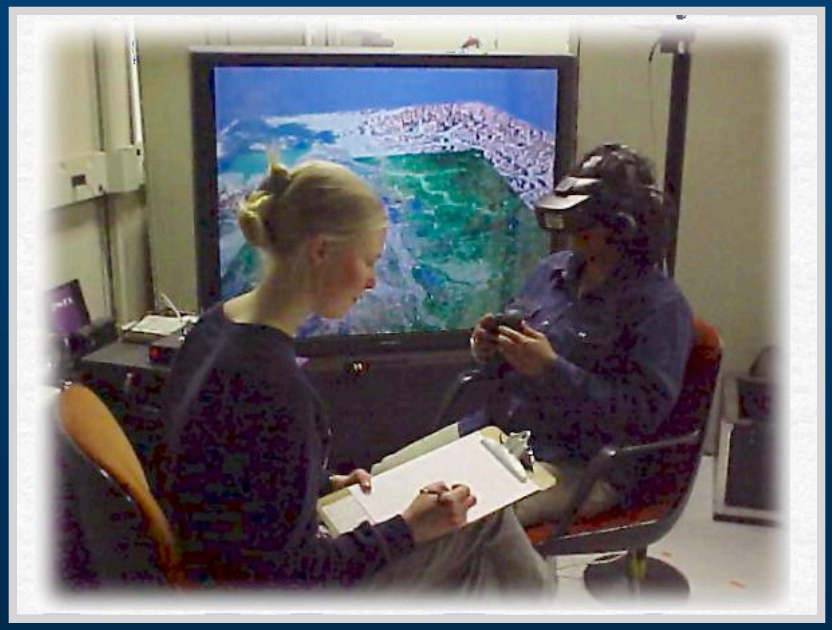


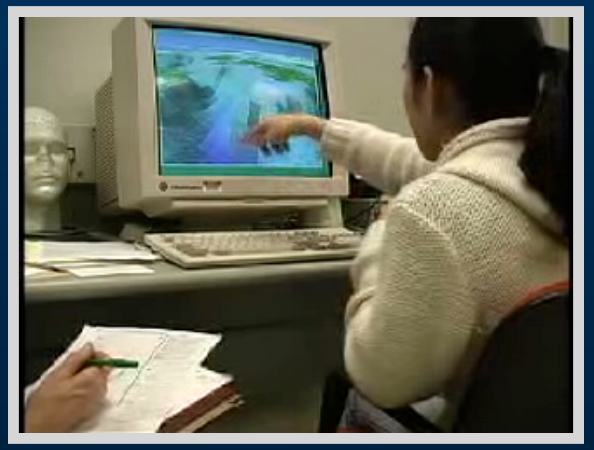


Virtual Puget Sound –Desktop



VPS Studies



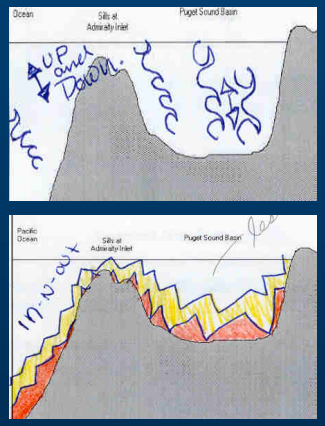


Three lab-based studies:

- Interface and Visualization Issues
- Middle School Students-paired
- Immersed vs Desktop Comparison

Middle School Study Results

BEFORE:



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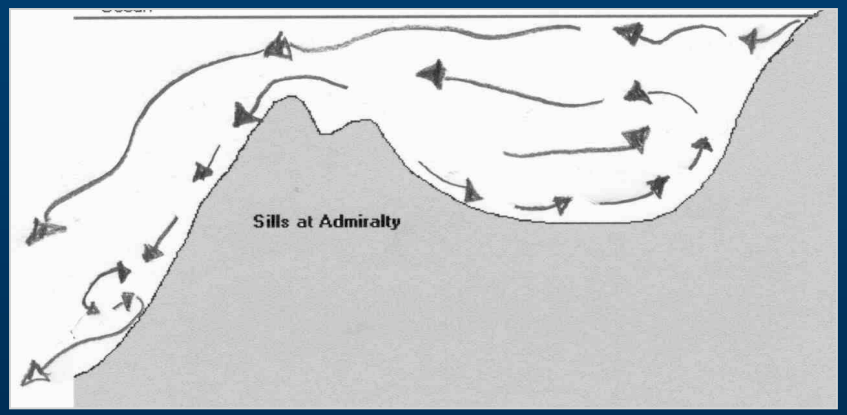

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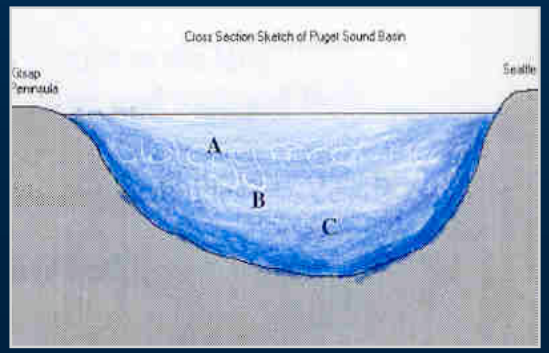

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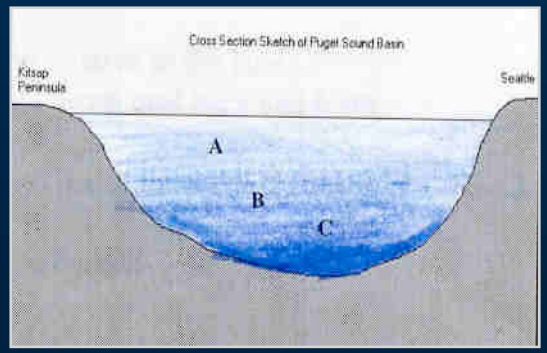
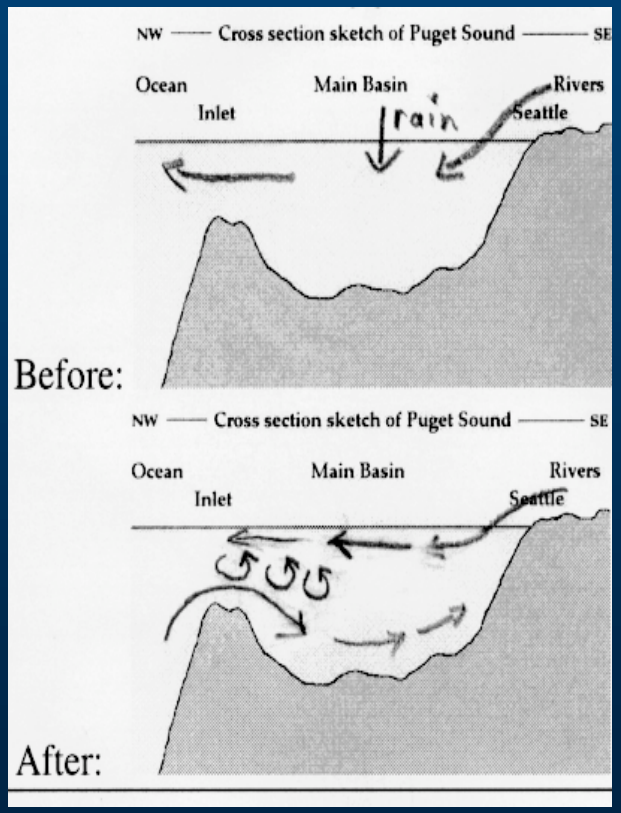
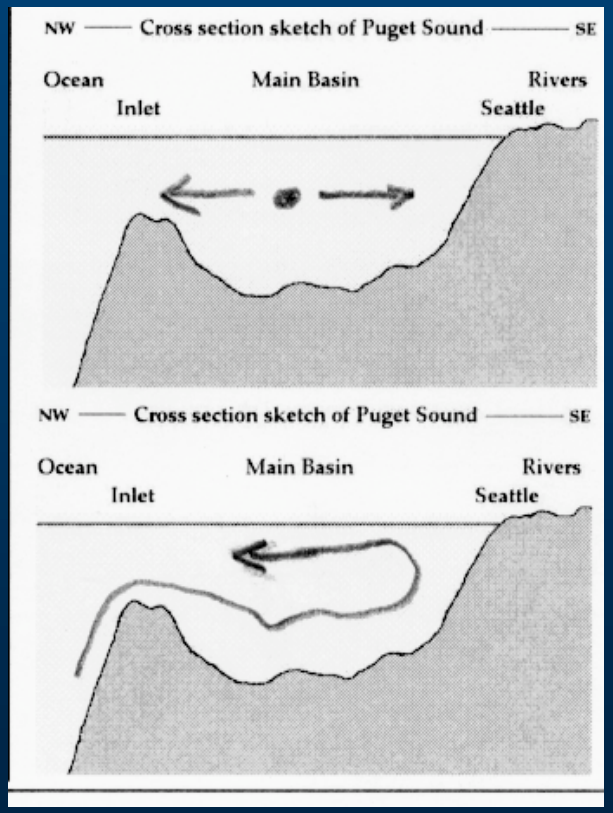
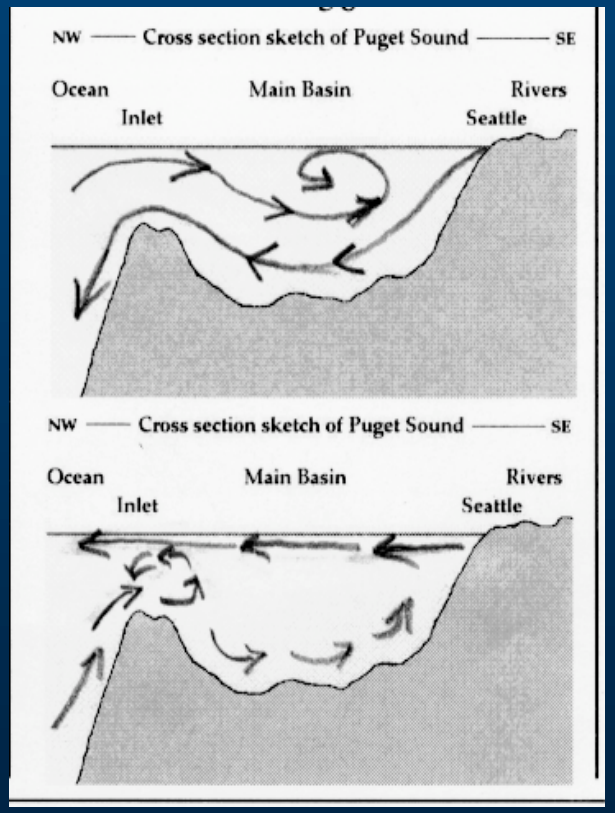


VPS and Field Comparison Study







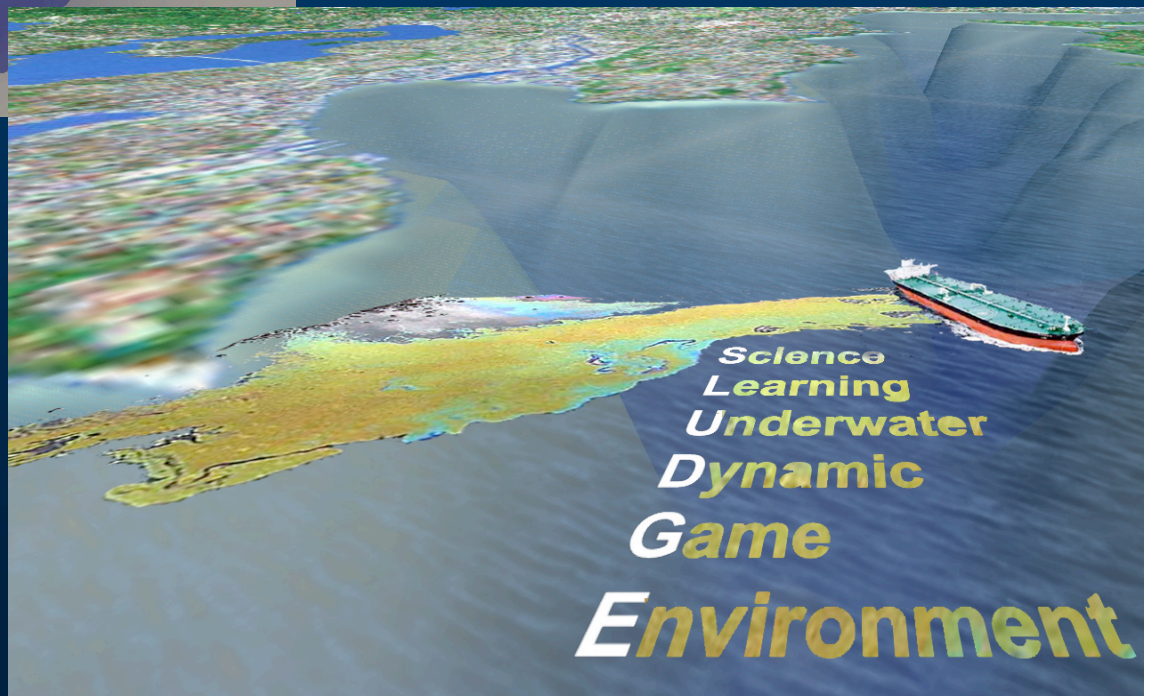
Virtual Puget Sound –

The Next Generation

Finding Luna

Learning science by solving problems

Learning science and crisis management



Future . . .

Serious Games: is that the way to go?