

How Can the History and Philosophy of Science Contribute to Contemporary U.S. Science Teaching

Friday, 07 December 2012

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Can Science Studies Help Shift Teachers into a More Sophisticated View of Learning? Toward an R & D Agenda

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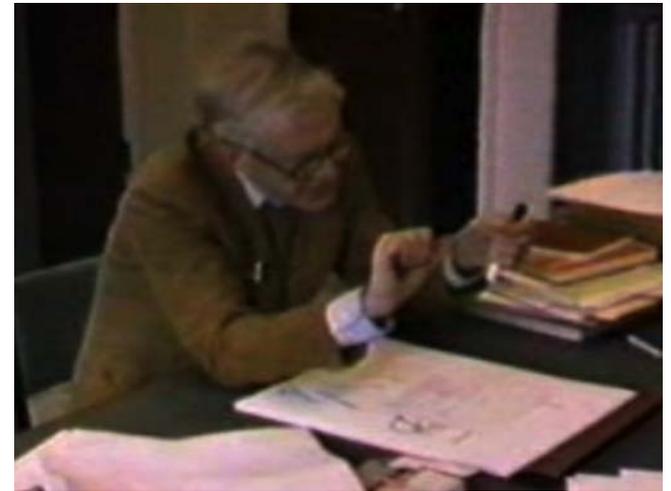
Can HPS/Science-Studies Help Shift Teachers to a More Sophisticated View of Learning? Toward an R & D Agenda

Questions

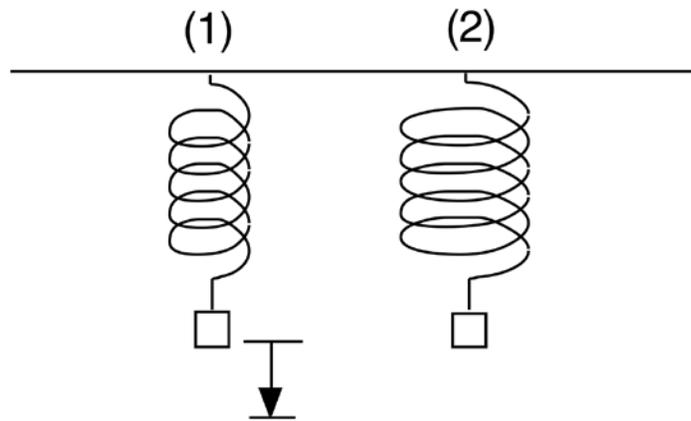
- Problem: Many teachers and trainees do not understand:
 - Central role of explanatory models in science
 - How complex model construction occurs as progressive cycle of generation, evaluation, and modification
 - How learning can depend on the student's prior knowledge resources
- How can we find transparent visual images of such learning processes to discuss with teachers that are:
 - Memorable
 - Simple

Think Aloud Studies of Science Experts

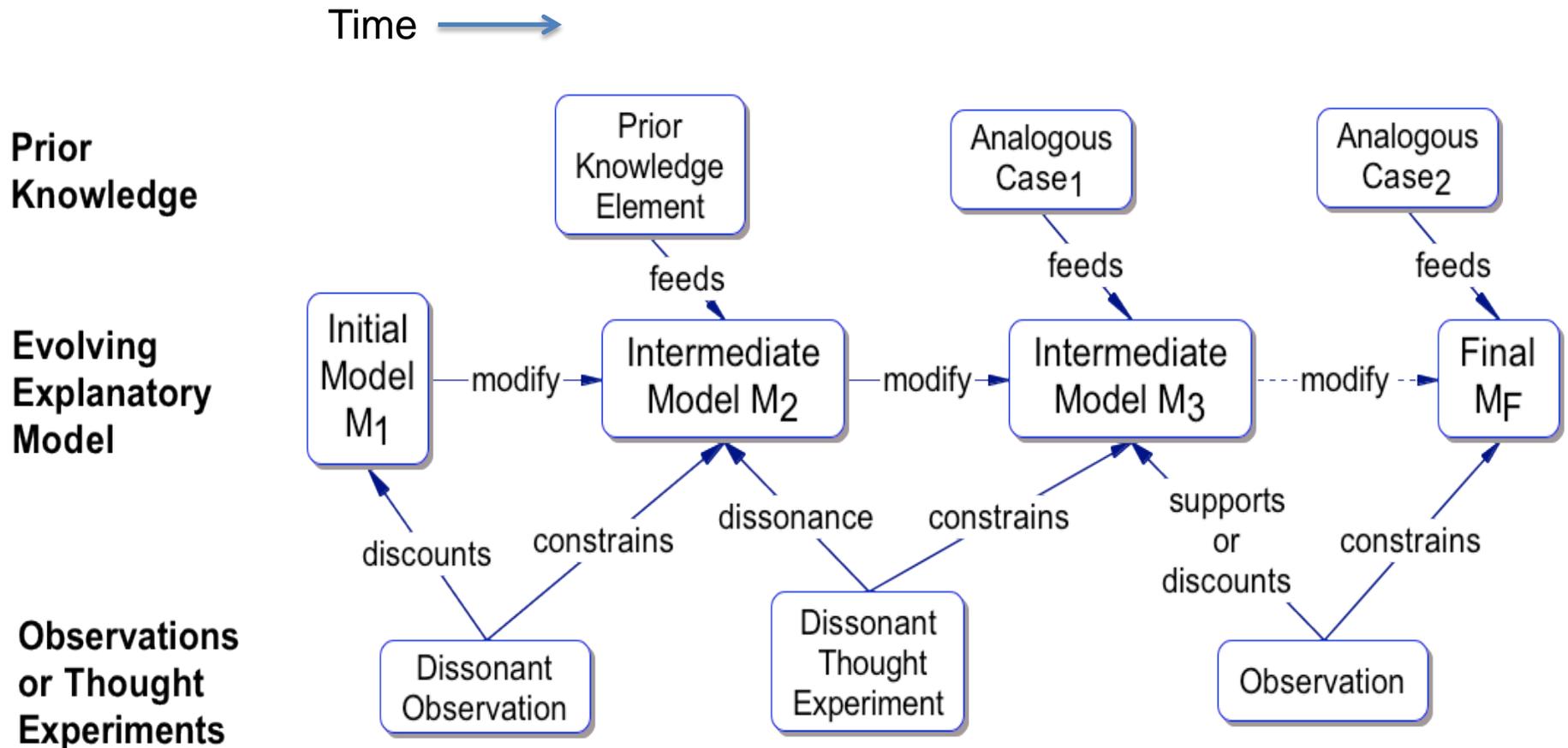
What Processes Do Experts use in Scientific Model Construction?



Spring Problem



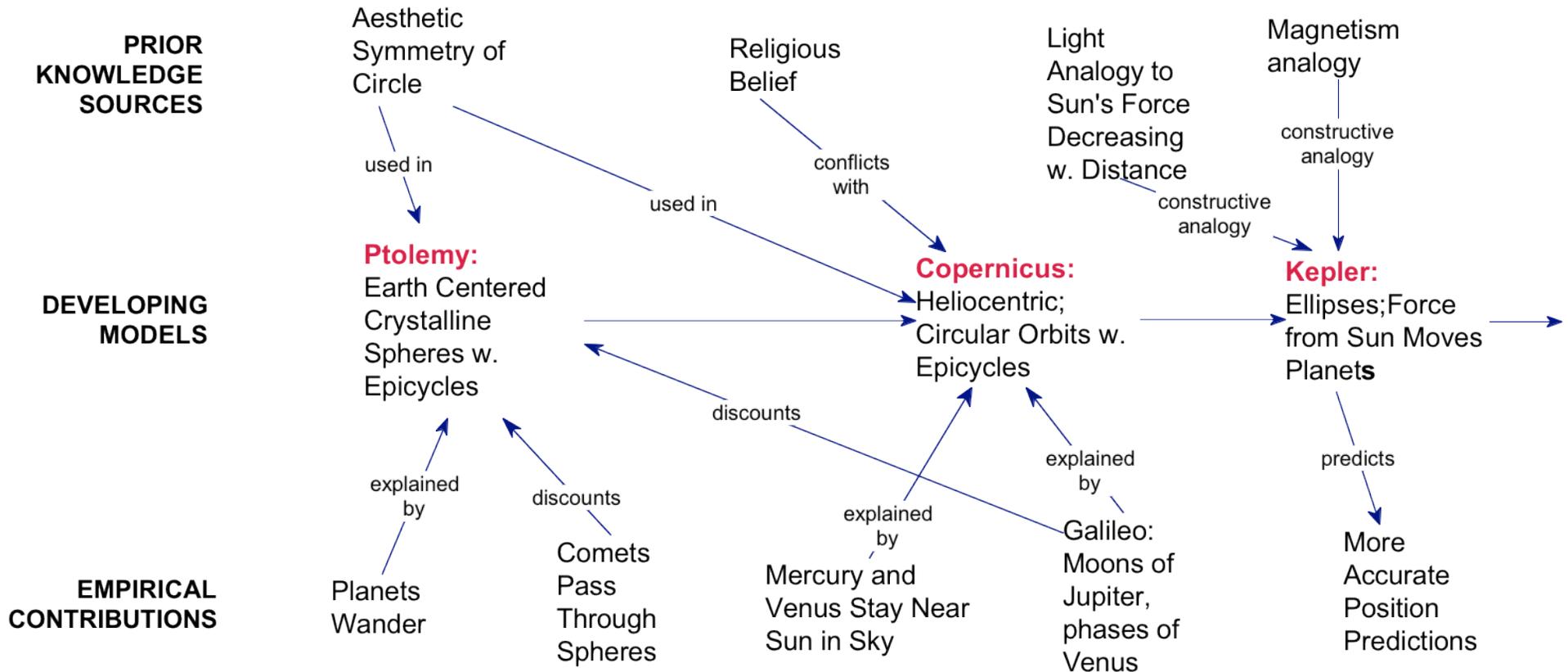
General Model Development Pattern as a Learning Process



Clement, J., (2009). *Creative Model Construction in Scientists and Students: The Role of Imagery, Analogy, and Mental Simulation*. Dordrecht: Springer.

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MODEL DEVELOPMENT IN THEORIES OF THE SOLAR SYSTEM



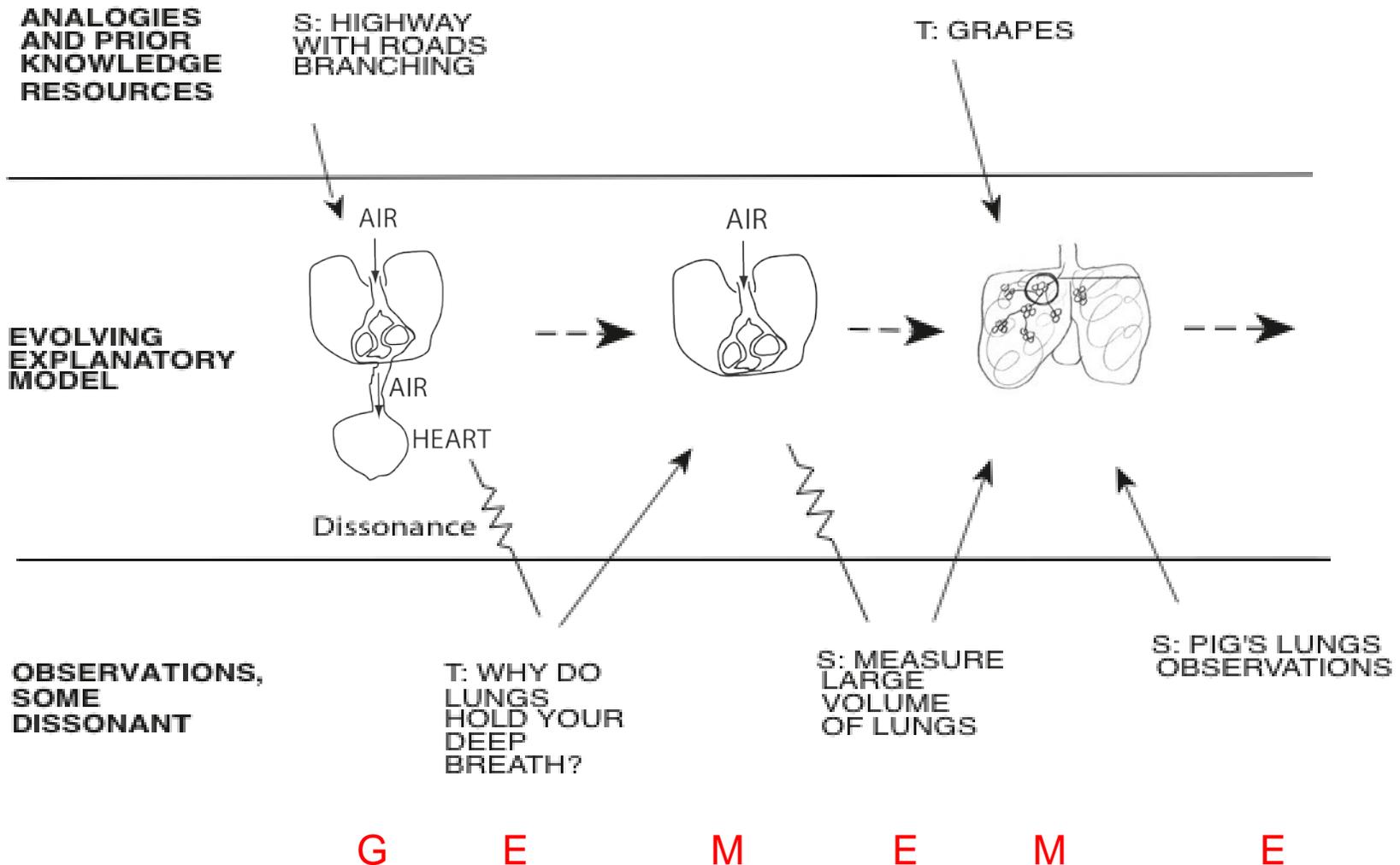
Themes

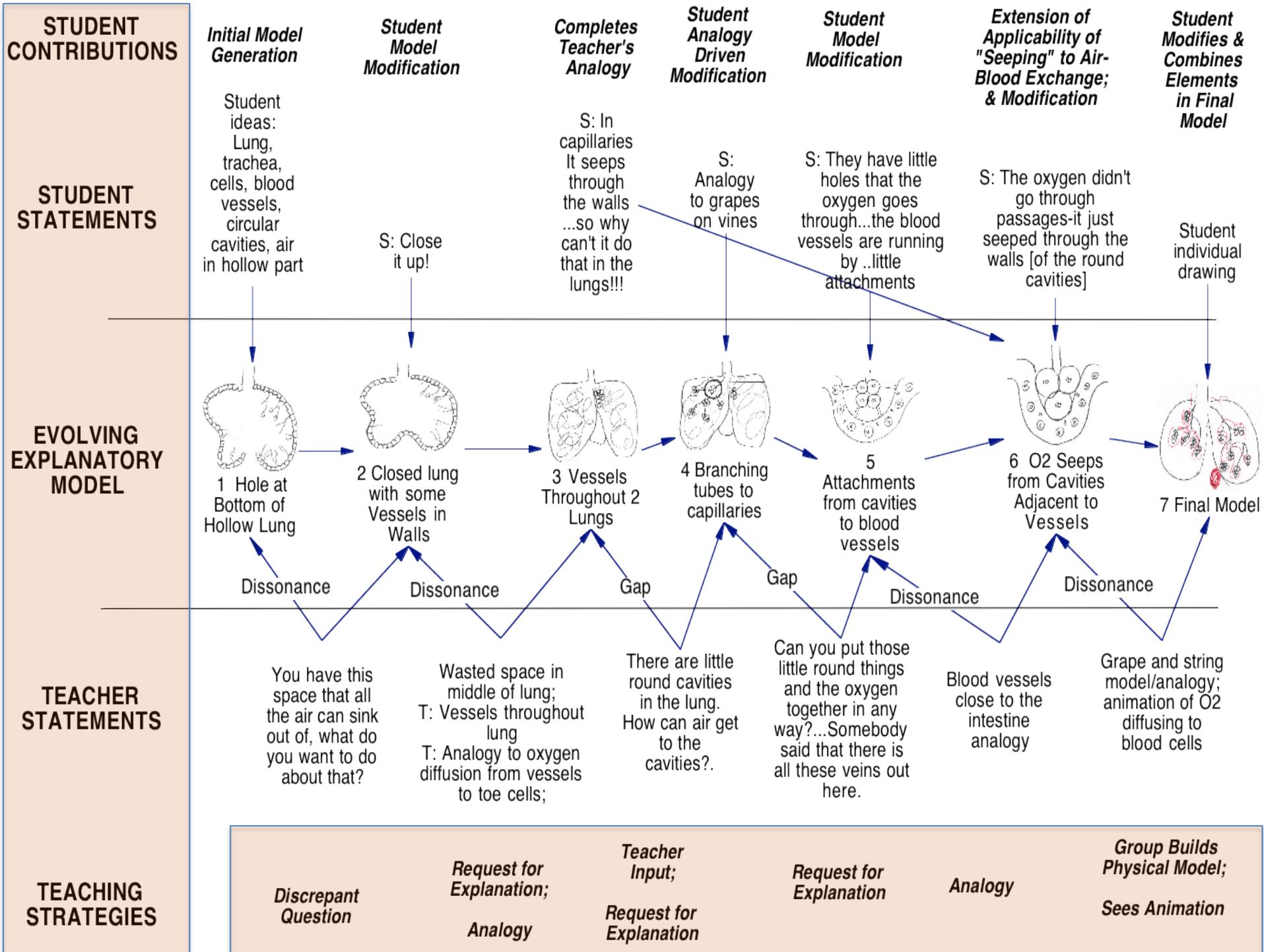
- Progressive Sequence of Partially Correct Hypothesized Models
- Cycle of Generation, Evaluation, and Modification
- Cycle Fed by both Empirical Contributions and Rationalistic Prior Knowledge Sources

Model Development in 7th Grade Unit on Lungs

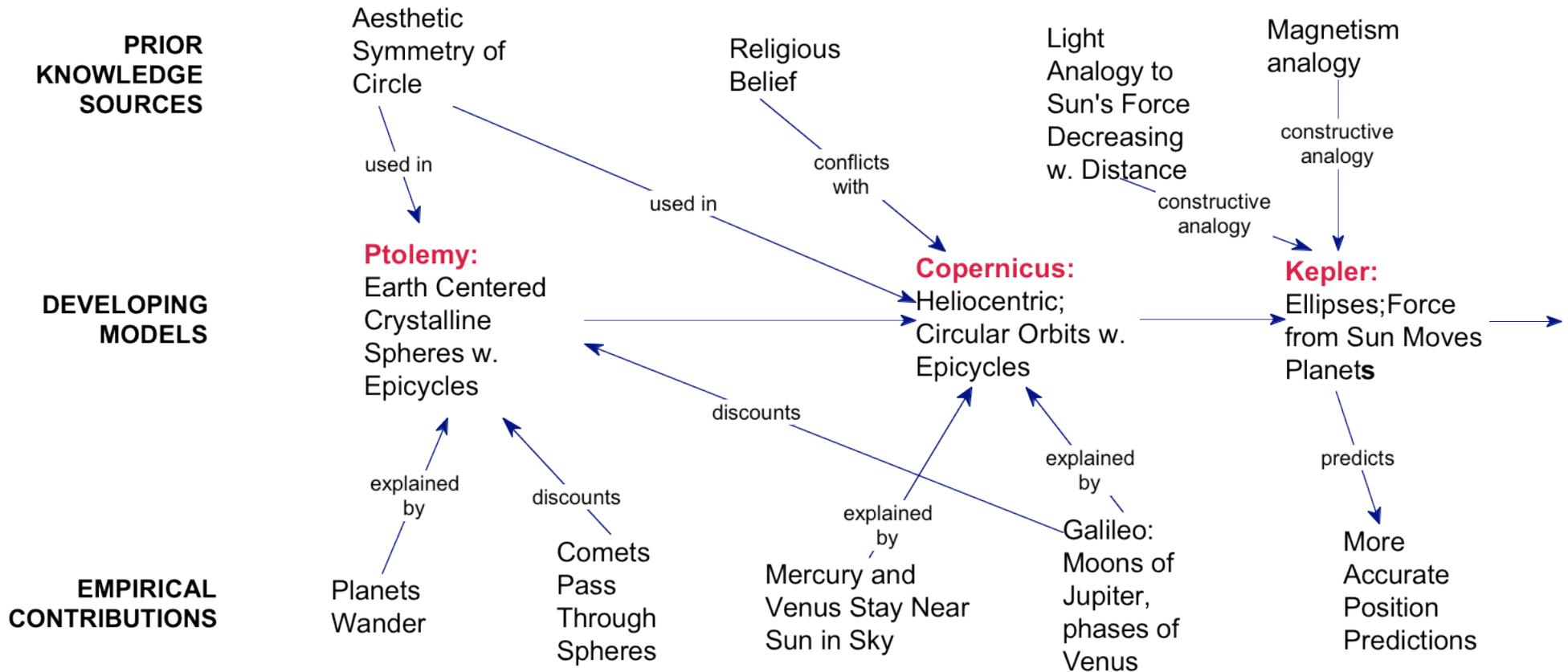
S= STUDENT
T= TEACHER

G = Model Generation
E = Model Evaluation
M = Model Modification



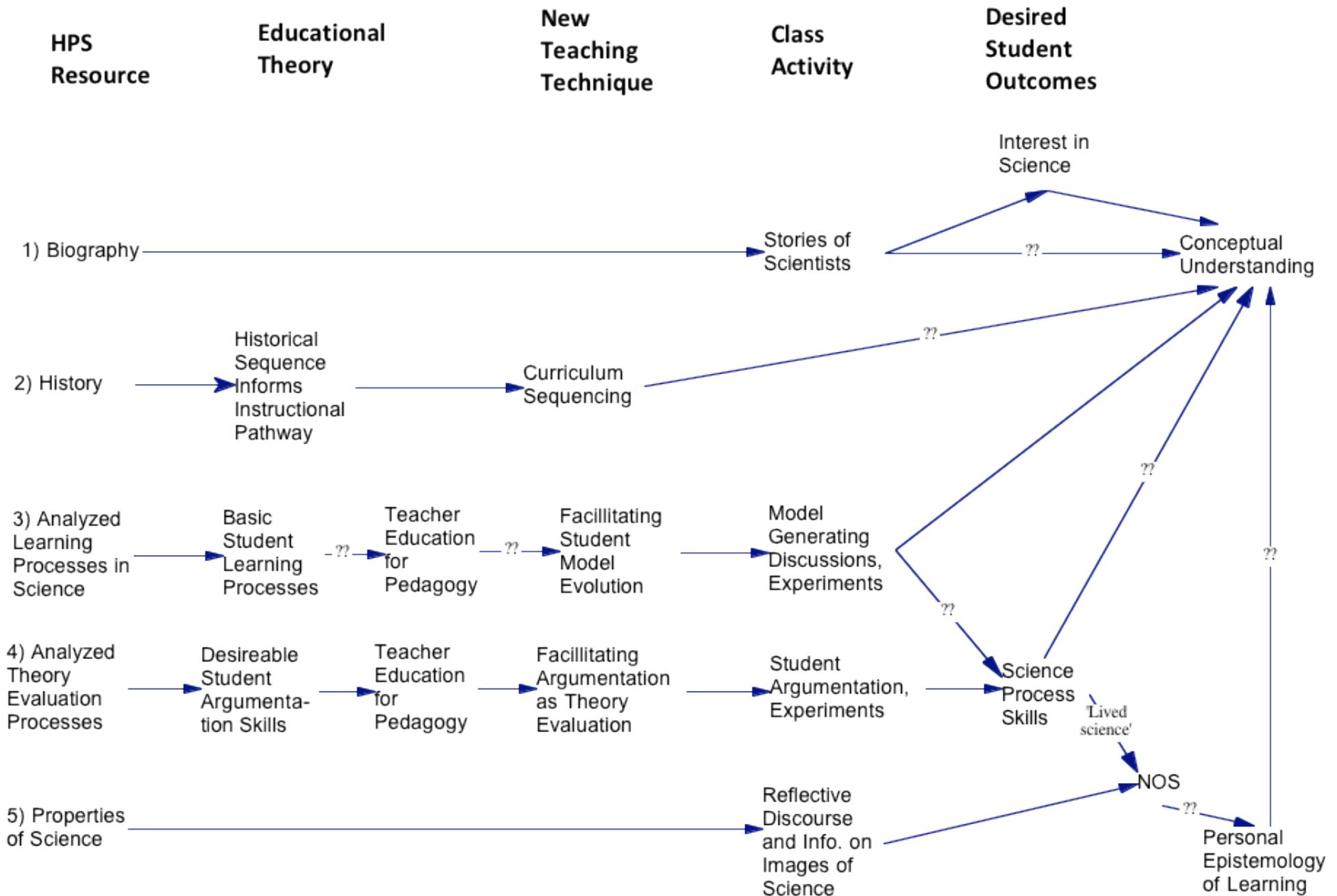


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Themes

- Progressive Sequence of Partially Correct Hypothesized Models
- Cycle of Generation, Evaluation, and Modification
- Cycle Fed by both Empirical Contributions and Rationalistic Prior Knowledge Sources



There are many possible avenues of applying HPS/Expert Studies findings to education. The avenue I happen to be working on is in row 3.
 J. Clement, 10/10/12

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Draft of Research Agenda

1. Find
Clearest
Accessible
HPS /
Science
Studies
Examples of
Model
Construction

2. Analyze
Key
Embedded
Constructivist
Elements in
Model
Development
Trajectory

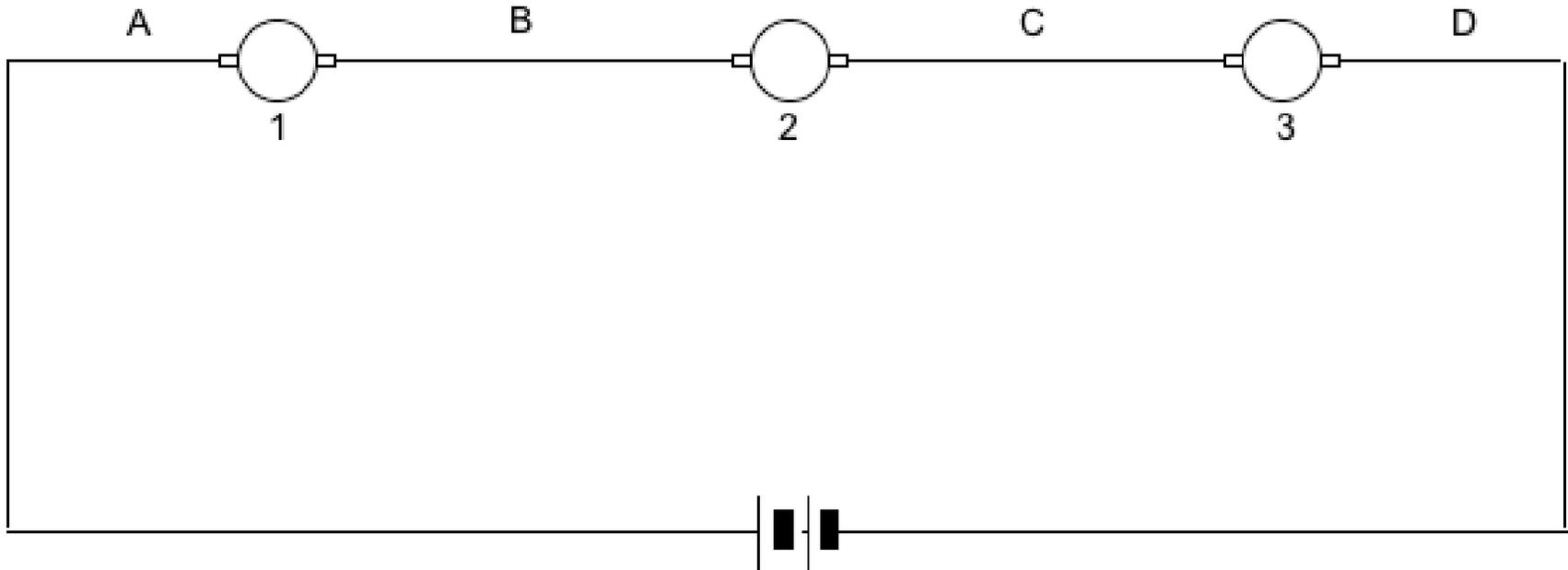
3. Develop
Transparent
Representations
of Learning
Process

4. Design
Professional
Development
Activities
Using These
Materials

5. Do Initial
Prof.
Development
Trial with
Formative
Evaluation

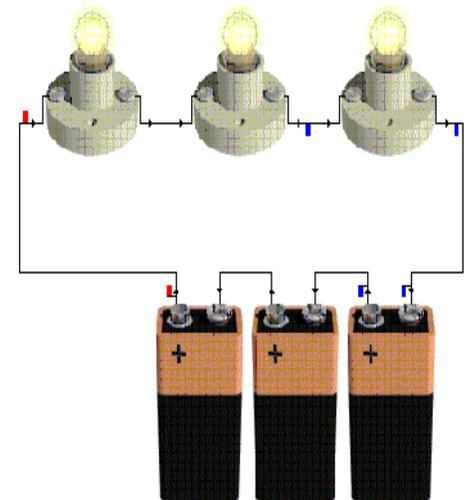
6. Do Larger
Trials with
Formative
and
Summative
Evaluation

Connections to Science Teaching



Adapted from:

Williams, E.G. (2011). *Fostering high school physics students' construction of explanatory mental models for electricity: Identifying and describing whole-class discussion-based teaching strategies*. Doctoral Dissertation. University of Massachusetts, Amherst.



) Student Statements

"I think the charge is just getting changed into heat in the light bulbs"

"Charge is like energy"

"That something's moving and they moved the same"

"It would get less hot"

) Evolving Explanatory Model

Electric Charge can be converted to heat by light bulbs

and Electric Charge is a type of energy

Compass deflection indicates same movement

Subsequent Bulbs would be cooler due to less charge flow



) Teacher Statements

"So, here's the big question - how do bulb filaments, the thing that glows, influence moving charge?"

" But is heat the same as charge?"

"What did the compass needle tell you was.. the rate of charge movement through these wires?"

"If charge is being changed into heat, what would you see..as you moved further..in the circuit?"

Level 3) Cognitive Teacher Moves - Macro Construction

G
Model Generation

M
Model Modification

E
Model Evaluation

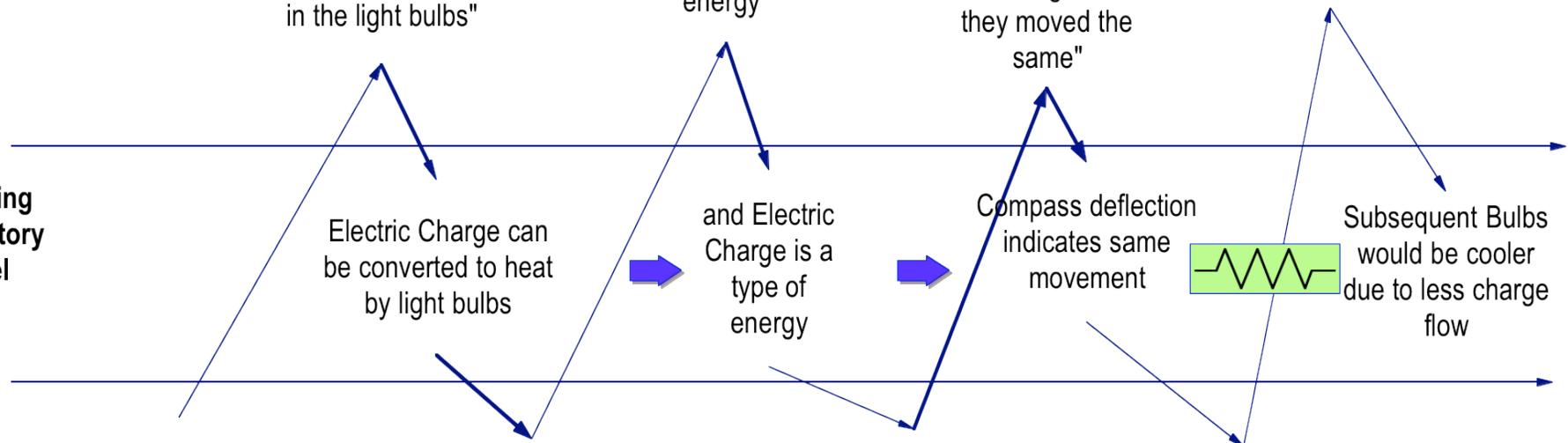
Level 2) Cognitive Teacher Moves - Micro

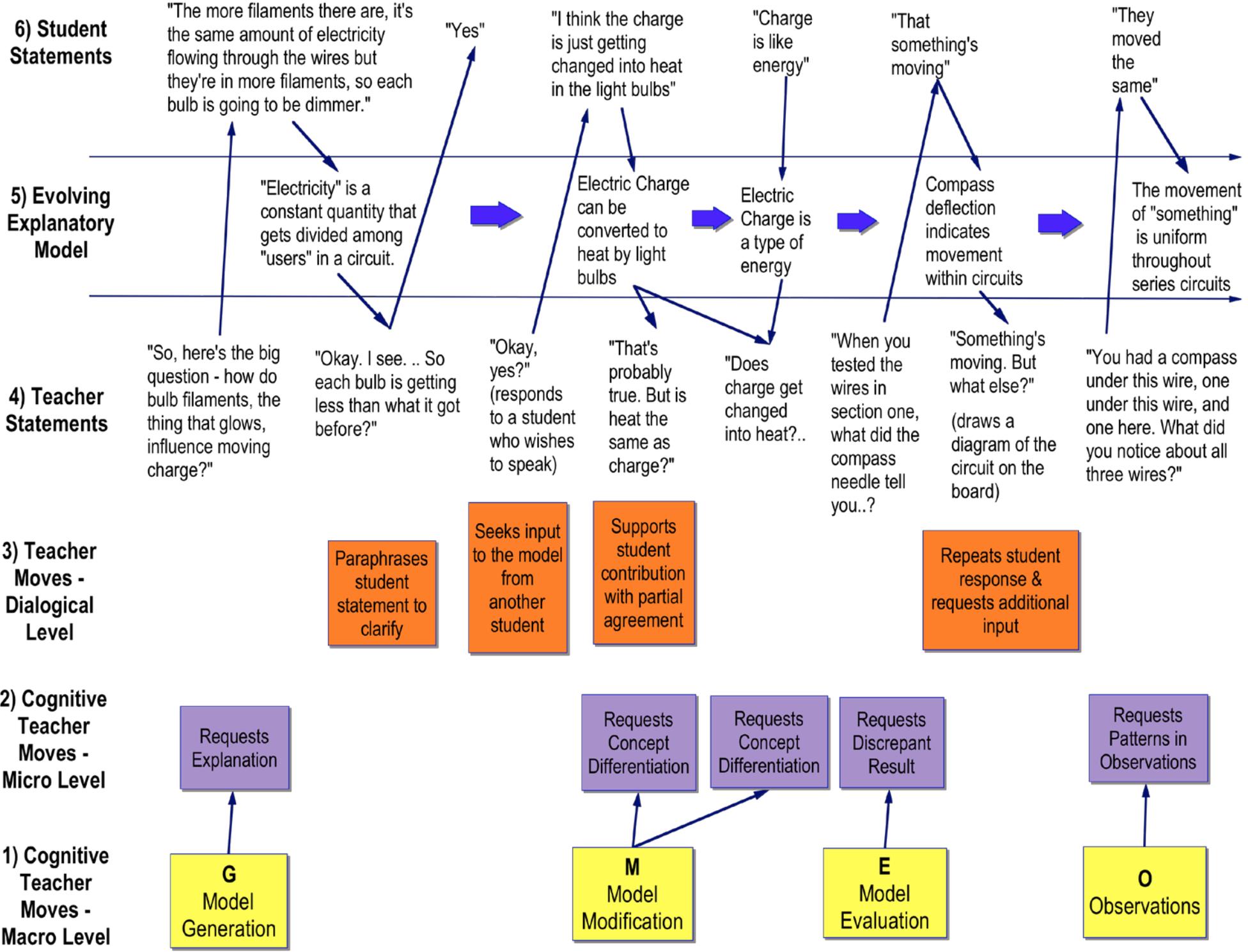
Requests Explanation

Requests Concept Differentiation

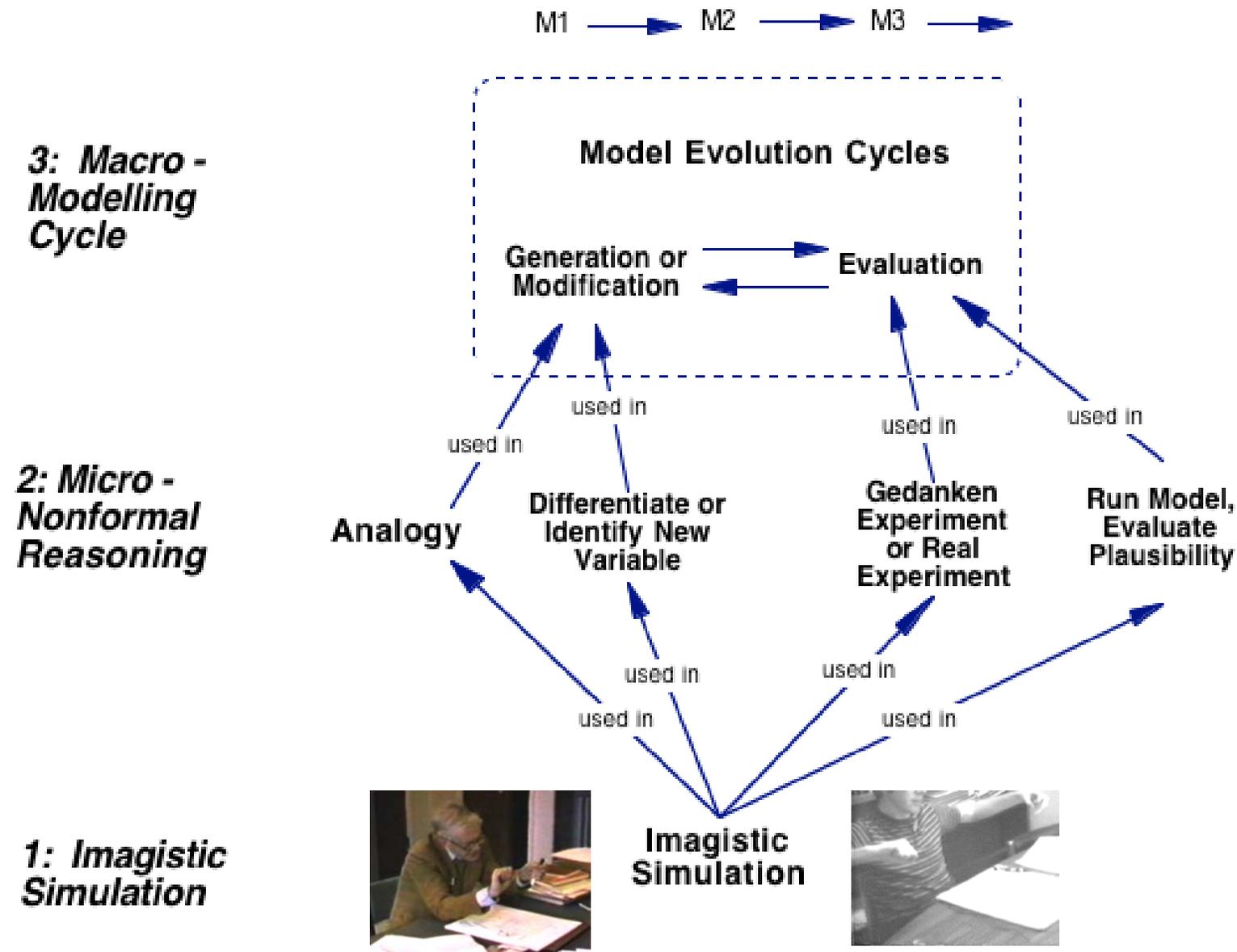
Requests Experimental Result

Requests Running The Model to Set Up Conflict





Three Nested Levels of Processing in Experts



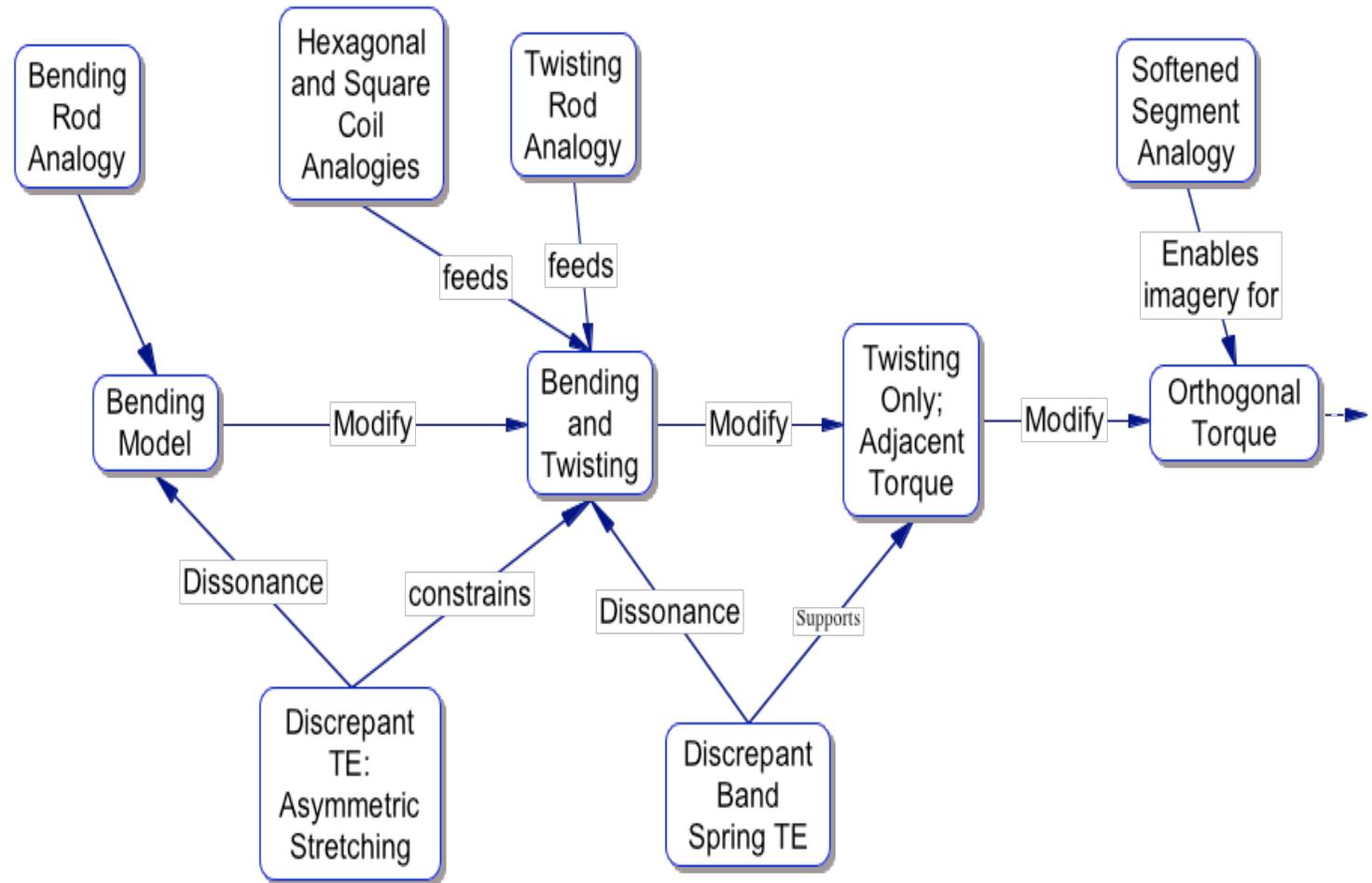
Clement, J., (2009). *Creative model construction in scientists and students: The role of imagery, analogy, and mental simulation*. Dordrecht: Springer.

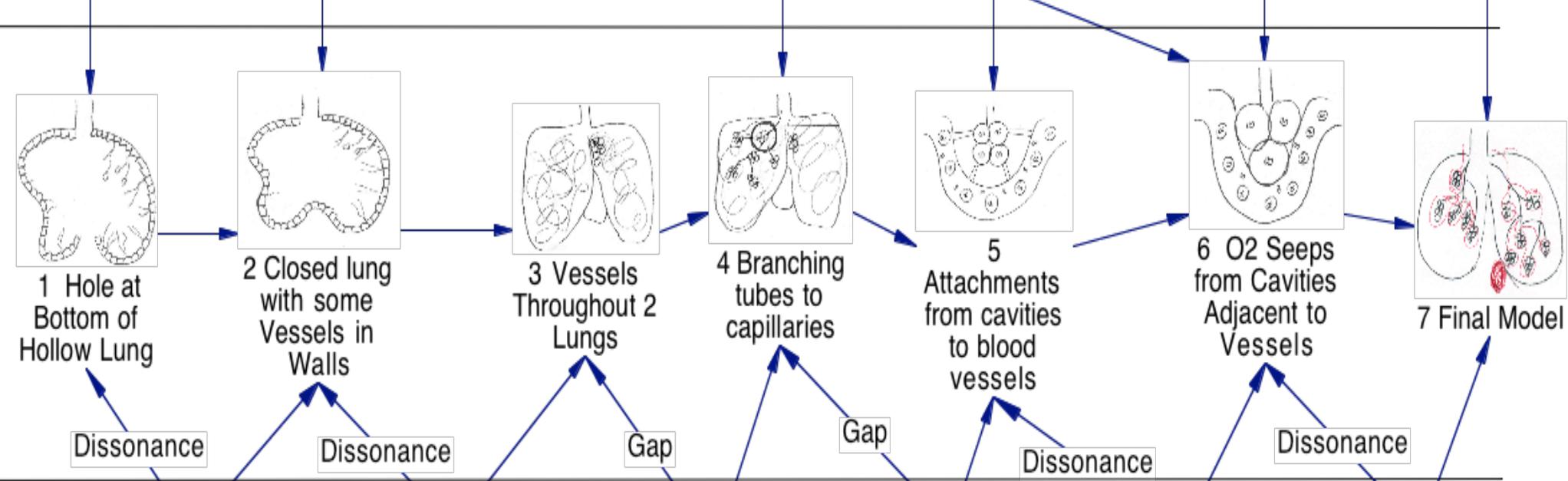
Model Evolution in an Expert

Prior Knowledge Contributions

Evolving Explanatory Model

Thought Experiments or New Observations





Dissonance

Dissonance

Gap

Gap

Dissonance

Dissonance

You have this space that all the air can sink out of, what do you want to do about that?

Wasted space in middle of lung;
T: Vessels throughout lung
T: Analogy to oxygen diffusion from vessels to toe cells;

There are little round cavities in the lung. How can air get to the cavities?.

Can you put those little round things and the oxygen together in any way?...Somebody said that there is all these veins out here.

Blood vessels close to the intestine analogy

Grape and string model/analogy; animation of O₂ diffusing to blood cells

Discrepant Question

Request for Explanation;
Analogy

Teacher Input;
Request for Explanation

Request for Explanation

Analogy

Group Builds Physical Model;
Sees Animation

**HPS /
Expert
Studies**

Analyzed
Learning
Processes



**Ed
Theory
for
Teachers**

Image of
Science
Learning
Processes:
e.g. Model
Construction



**New
Teaching
Technique**

Model
Generating
Discussions,
Experiments



**Student
Outcomes**

Conceptual
Understanding

