Can New Learning Models Provide Useful Insights for Assessment?

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CMMAP Team Meeting

Ft. Collins, CO

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CMMAP Education Mission

Educate and train people with diverse backgrounds in Climate and Earth System Science by enhancing teaching and learning...

So...what did you do on sabbatical?
Did this enhance the CMMAP education mission?

- *Certificate in lectical analysis
- Develop Catamount Center SEE Program (fall 2014)
- Faculty development grant on reflective judgement (summer 2014)
- Integral Practitioner certificate
- Home school my sixth-grade daughter
- *Contemplative environmental studies workshop
- Practice Tai Chi "religiously"
- Santa Fe Institute MOOC on complexity
- *Seven weeks studying Spanish in Panama (2013)

Presentation Outline

- What models help us understand the individual's development of knowledge (genetic epistemology)?

   Jean Piaget: process, methodology, genetic epistemology

   Common structure of neo-Piagetian theorists

   Kurt Fischer: skill theory

- Theo Dawson: lectical assessment & hierarchical complexity

   Methodology

   Examples

   Physics of energy assessment: K-12 students

   Developmental pedagogy assessment: Grad students

   Reflective judgement assessment: K-16

- Summary

Integral Epistemology Questions

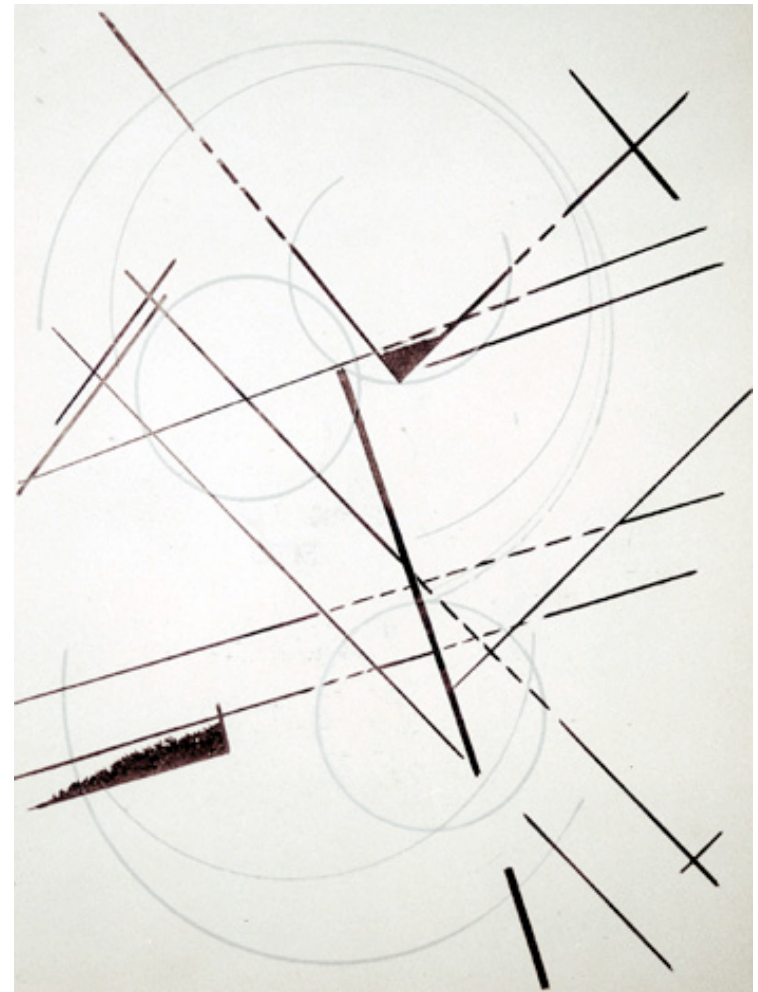|	**Interior**	**Exterior**
Individual	**How do I come to know?** Cognitive constructivism	**What observable evidence exists for learning?** Student assessment Neuroscience studies
Collective	**How do students learn?** Social constructivism (POGIL)	**What structures promote learning?** Developmental models Cognitive science models

Constructivist philosophy simplified

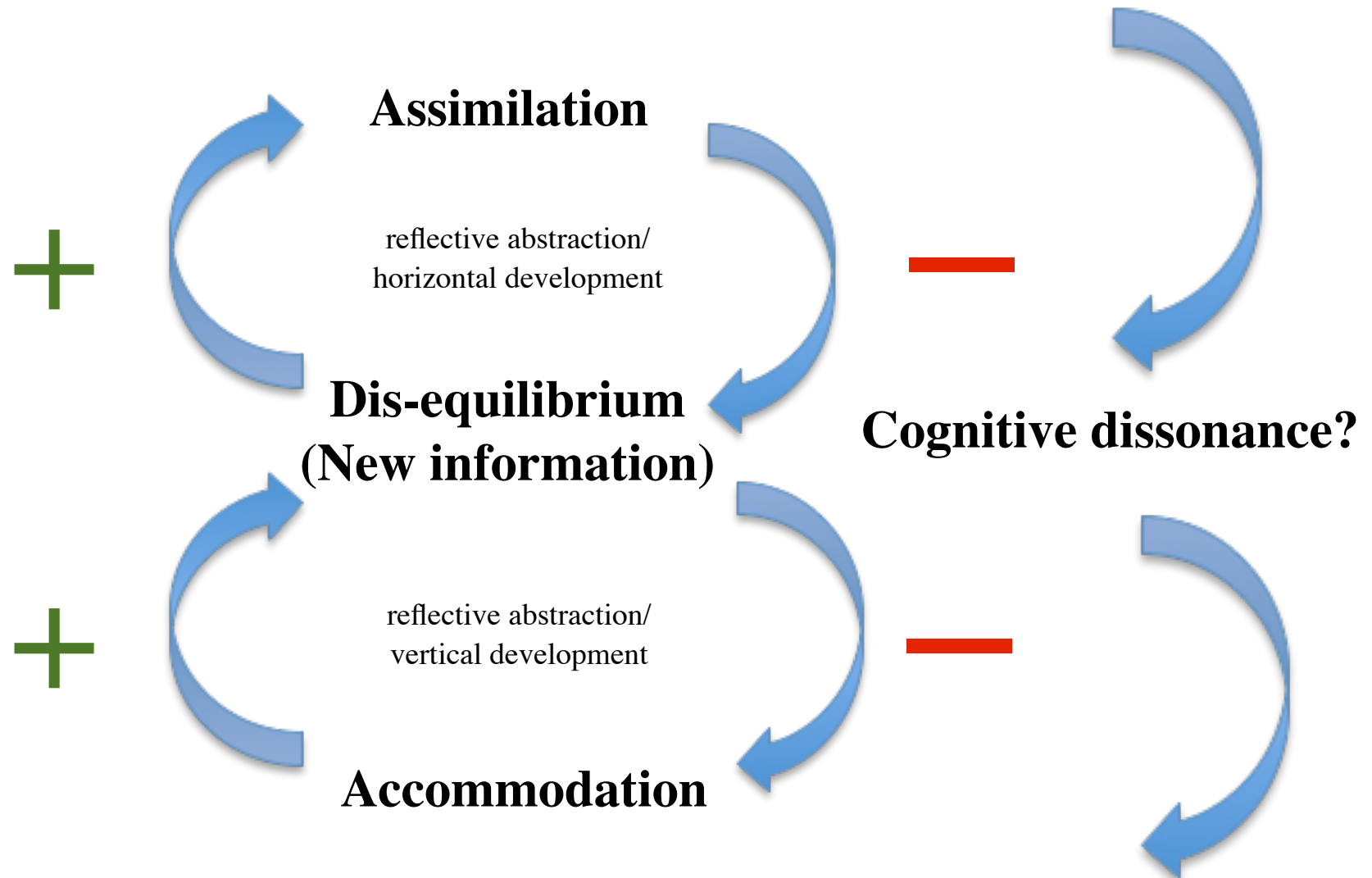**Cognitive constructivism (Piaget):** Knowledge is constructed due to active mental activity of the learner and not transferred directly from teacher to learner.

Social constructivism (Vygotsky): It is in the process of articulating, reflecting and negotiating that we engage in a knowledge construction process.

Piaget primer 1: learning mechanisms: Learning as *equilibration*

Assimilation

reflective abstraction/
horizontal development

+

−

**Dis-equilibrium
(New information)**

Cognitive dissonance?

+

reflective abstraction/
vertical development

−

Accommodation

Quiz Question 1:
Learning as Equilibration

A young child growing up on a farm for several years learns about horses. The first time the child goes to the zoo, she sees a zebra and exclaims, "look mom, a black and white horse." Is this an example of accommodation or assimilation?

Piaget primer 2:
Genetic epistemological methodology

"In a few words, the method to follow in the study of children's representation of the world is this: observe the child naturally, note the child's utterances and questions, and then, inspired by these questions, interview other children directly; finally return to pure observation in order to verify the results of previous interviewing."
Piaget, 1925

How do children develop knowledge relating to: logic, numbers, space, time, speed, moral reasoning...?
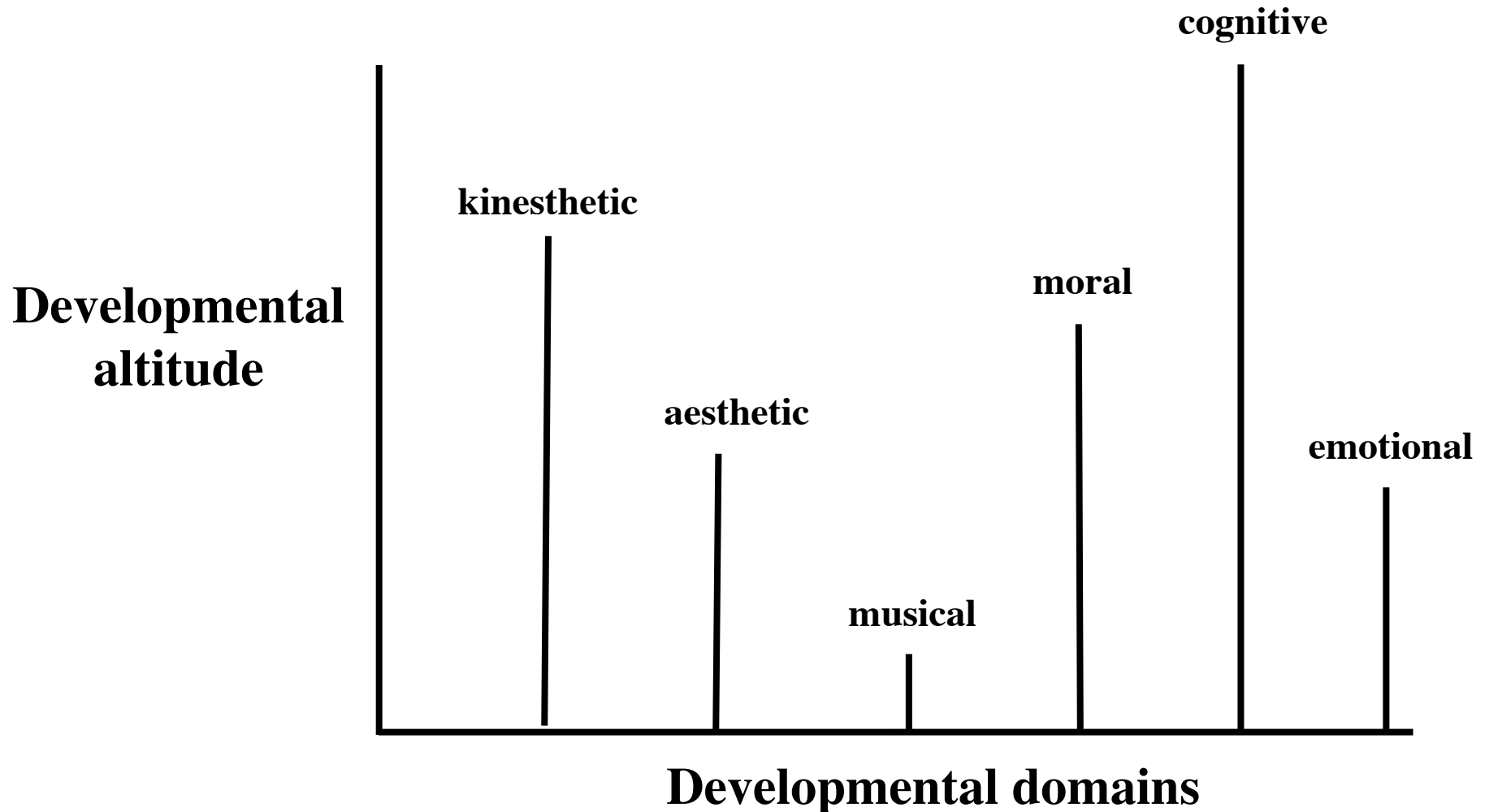
Jean Piaget, 1896-1980

Piaget primer 3:
Learning as stages of development

- **Sensorimotor**: early childhood development

- **Pre-operational**: represent objects with symbols

- **Concrete operational**: mentally manipulate representations

- **Formal operational**: ability to work with abstractions

Development along different domains
(Howard Gardner)

Notable neo-Piagetian theorists

COGNITION

- Michael Commons - general stage scoring system
- Kurt Fischer - hierarchical complexity

- Patricia King & Karen Kitchener - reflective judgement
- William Perry - epistemological reasoning
- Cheryl Armon - good life
- Lawrence Kohlberg - morals
- Robert Kegan - self

# Comparative genetic epistemologies

|	Skill levels (Fischer)	GSSS (Commons)	SISS (Kohlberg)	GLSS (Armon)	RJ (Kitchener & King)	SOI (Kegan)
14	principled systems	cross-paradigmatic				
13	principled mappings	paradigmatic	stage 6		stage 6 & 7	
12	single principles	meta-systemic	stage 5	stage 5	stage 5	interindividual
11	abstract systems	systemic	stage 4	stage 4	stage 4	institutional
10	abstract mappings	formal	stage 3	stage 3	stage 3	interpersonal
9	single abstractions		stage 2			
8	representa-tional systems	concrete		stage 2		imperial
7	representa-tional mappings	primary	stage 1			
6	single representations	pre-operational		stage 1		impulsive

Kurt Fischer's skill theory

More complex skills (structures) emerge from the integration and differentiation of simpler structures.

- Single Representations

  - Mapping Representations

  - Systems of Representations

- Single Abstractions

  - Mapping Abstractions

  - Systems of Abstractions

- Principles
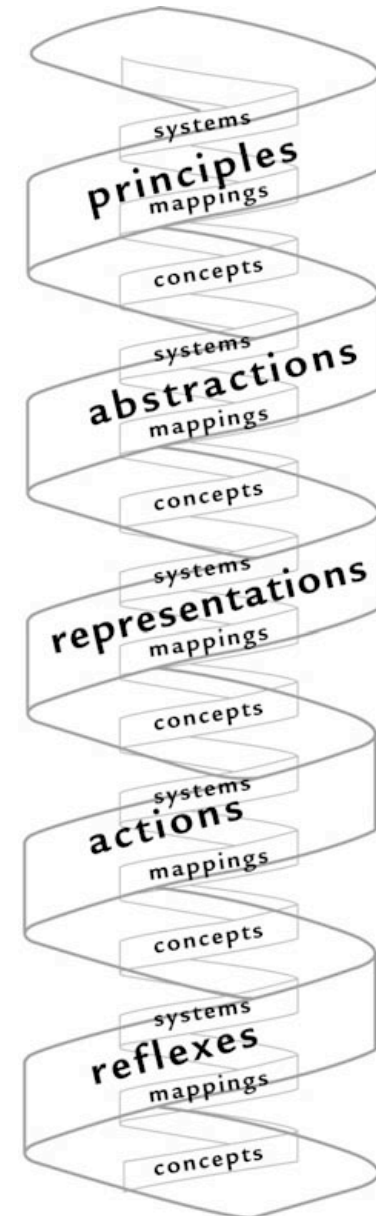
# Fischer's skill theory: Representations
(Models)

© Paul Foreman http://www.mindmapinspiration.com
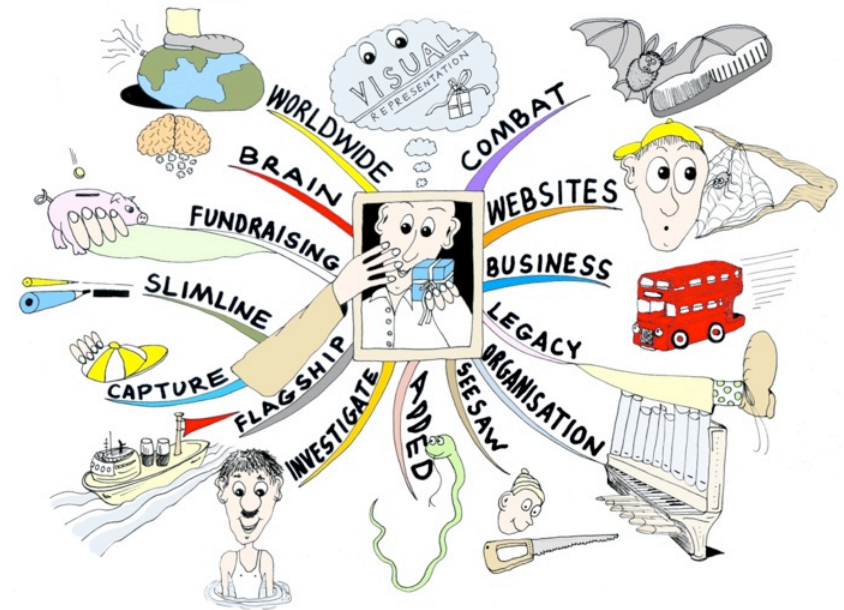
- Single Representations:
  – "That model rocket is cool"

- Mapping representations (coordinates one aspect of two or more representations):
  – "Models are things that I can build"

- Systems of representations (coordinates multiple aspects of two or more representations):
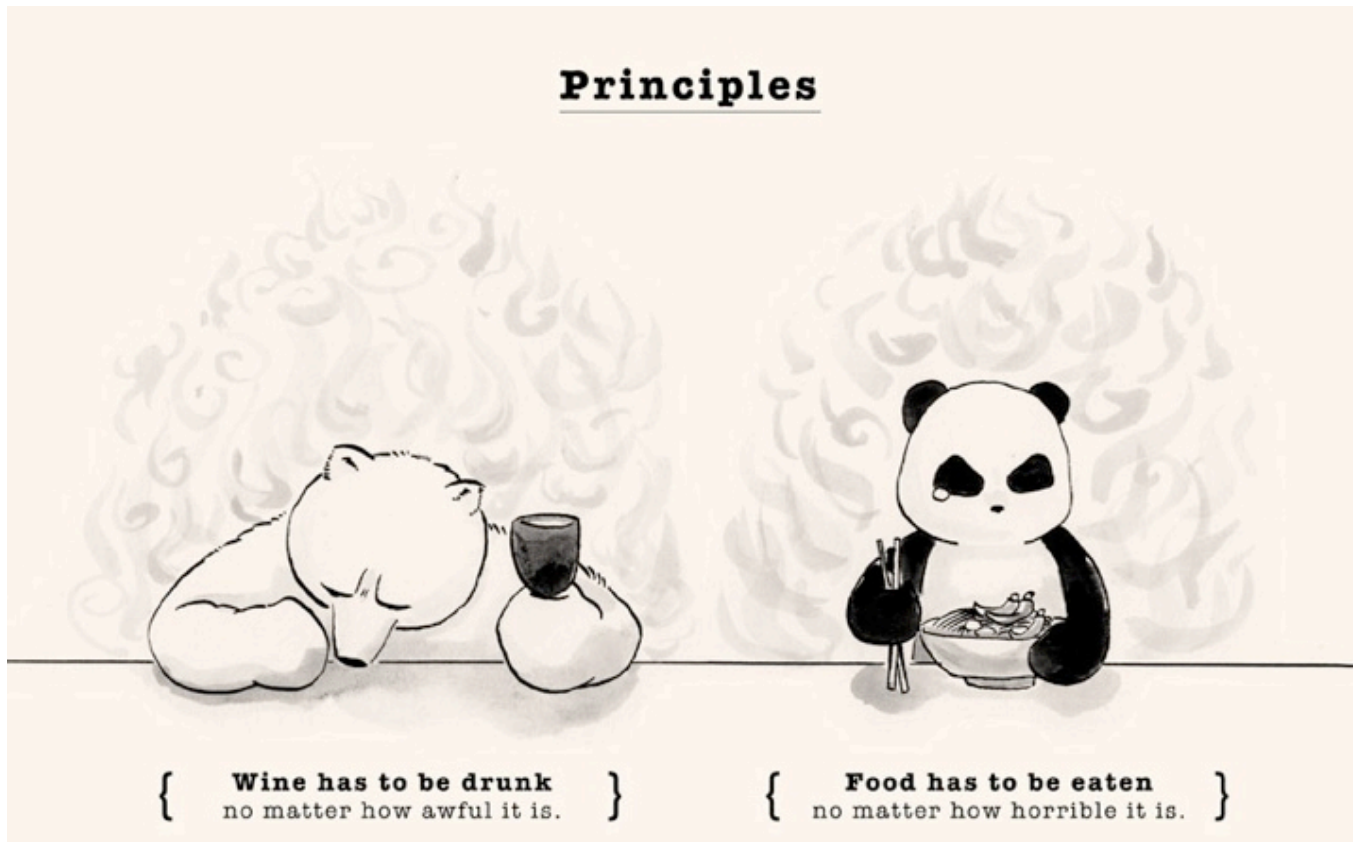 - "People make models to help them understand things."

Fischer's skill theory: Abstractions
(Energy)

- Single Abstractions

  – "Potential energy is a form of energy"

  – "Kinetic energy is a form of energy"

- Mapping Abstractions (coordinates one aspect of two or more abstractions):

  – "Potential and kinetic energy can be interconverted"

- Systems of Abstractions (coordinates multiple aspects of two or more abstractions):

  – "Potential and kinetic energy can be inter-converted in a similar way as heat and work"
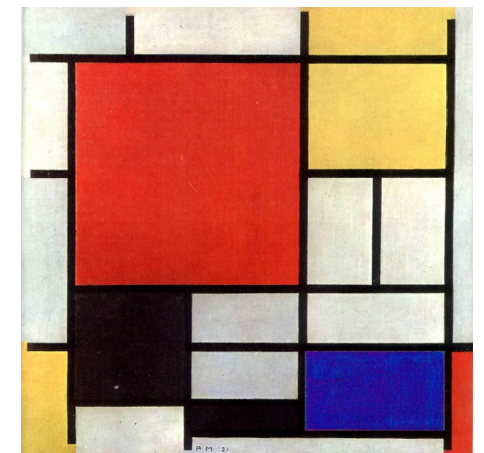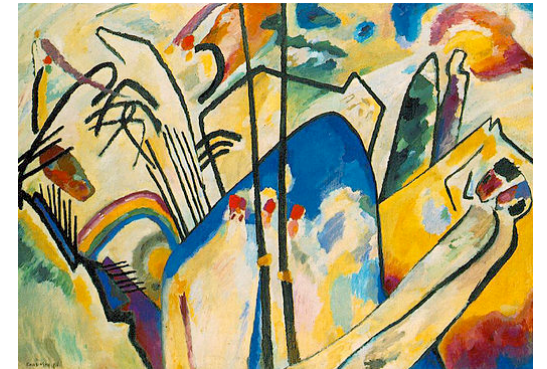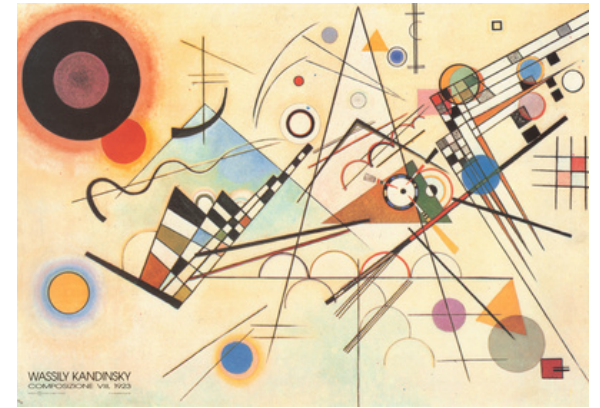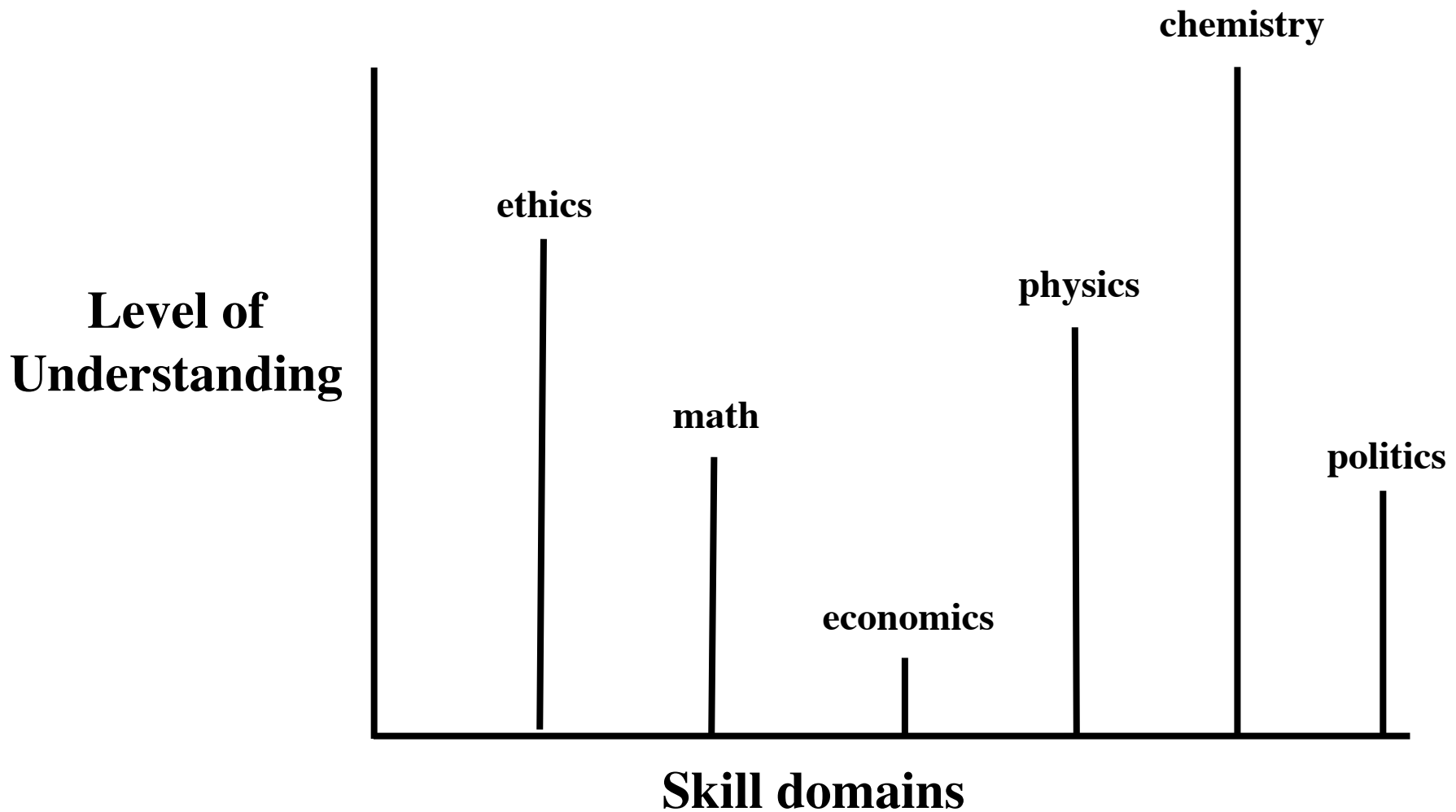
Fischer's skill theory: Principles

- Principles (identify one aspect of a principle coordinating abstract systems):

  - "Energy is conserved"

  - First law of thermodynamics

Principles

{ **Wine has to be drunk** }   { **Food has to be eaten** }
  no matter how awful it is.   no matter how horrible it is.

Skill development among domains

chemistry

ethics

physics

**Level of
Understanding**

math

politics

economics

Skill domains
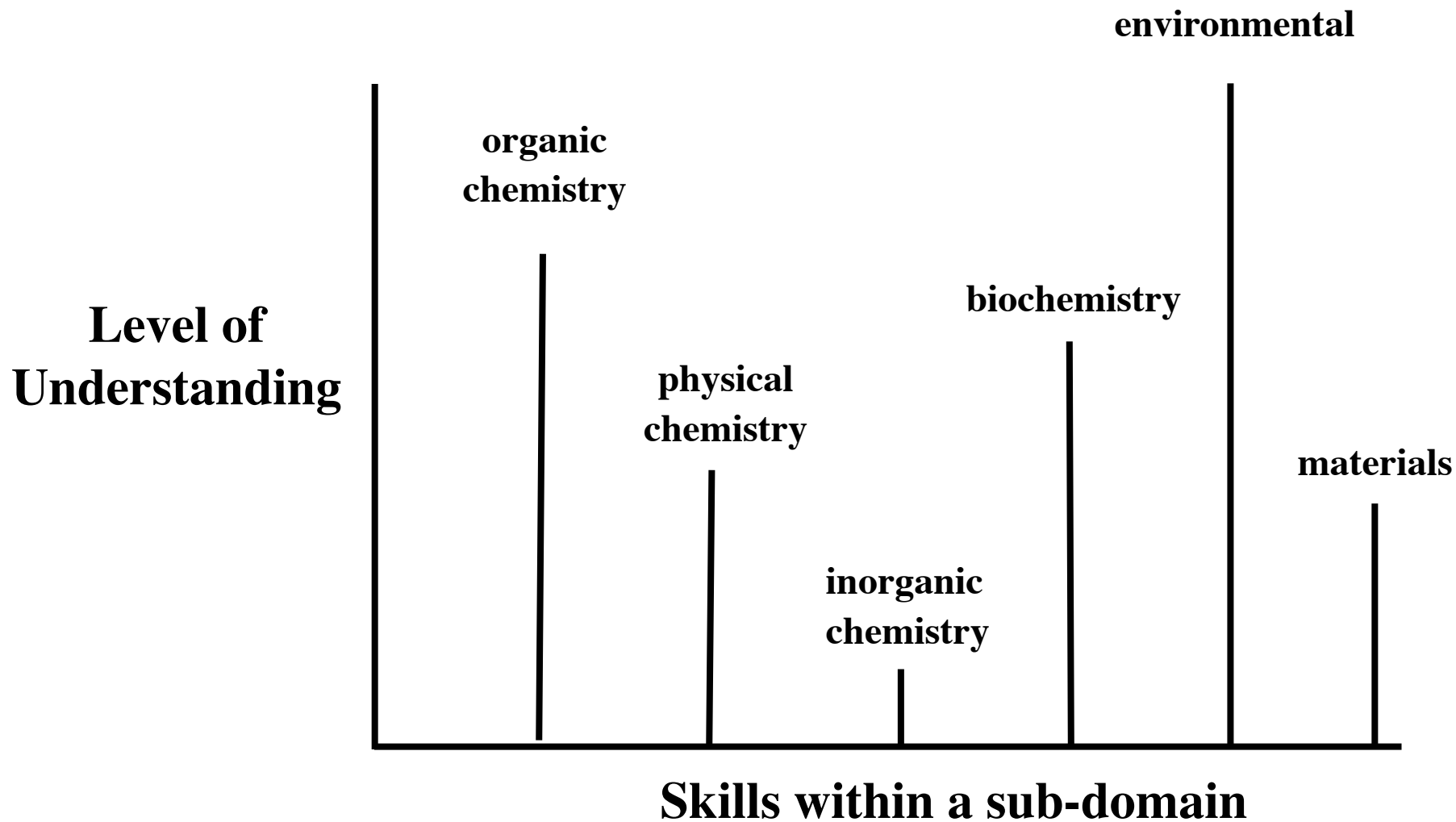
Conceptual skill development

Level of Understanding

thermodynamics

kinetics

statistical mechanics

dynamics

quantum mechanics

Skills within a theme
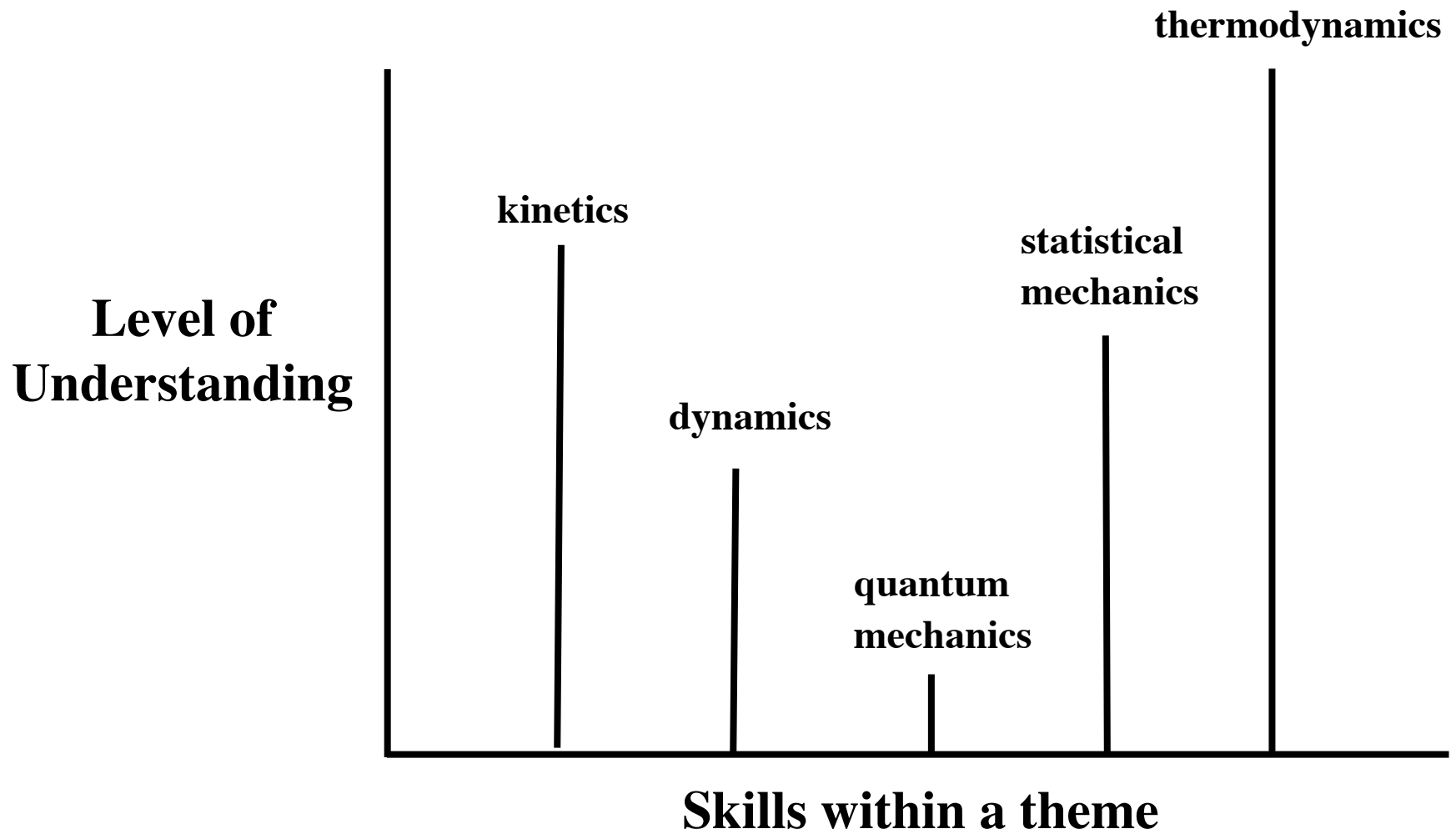
Levels of understanding: a cognitive ruler

Representations
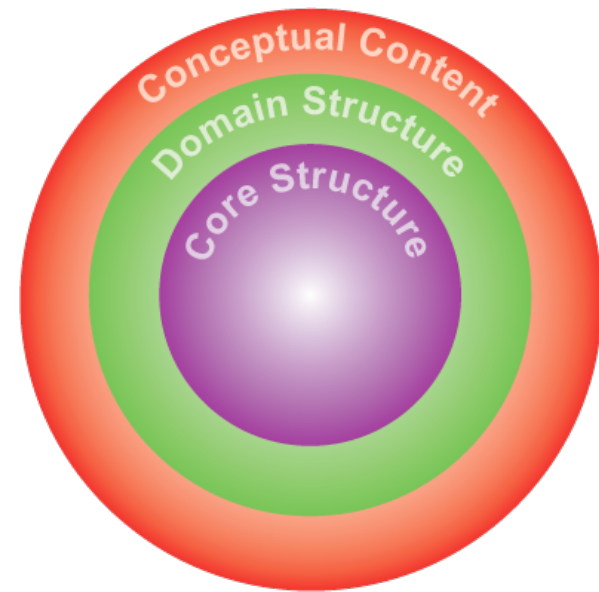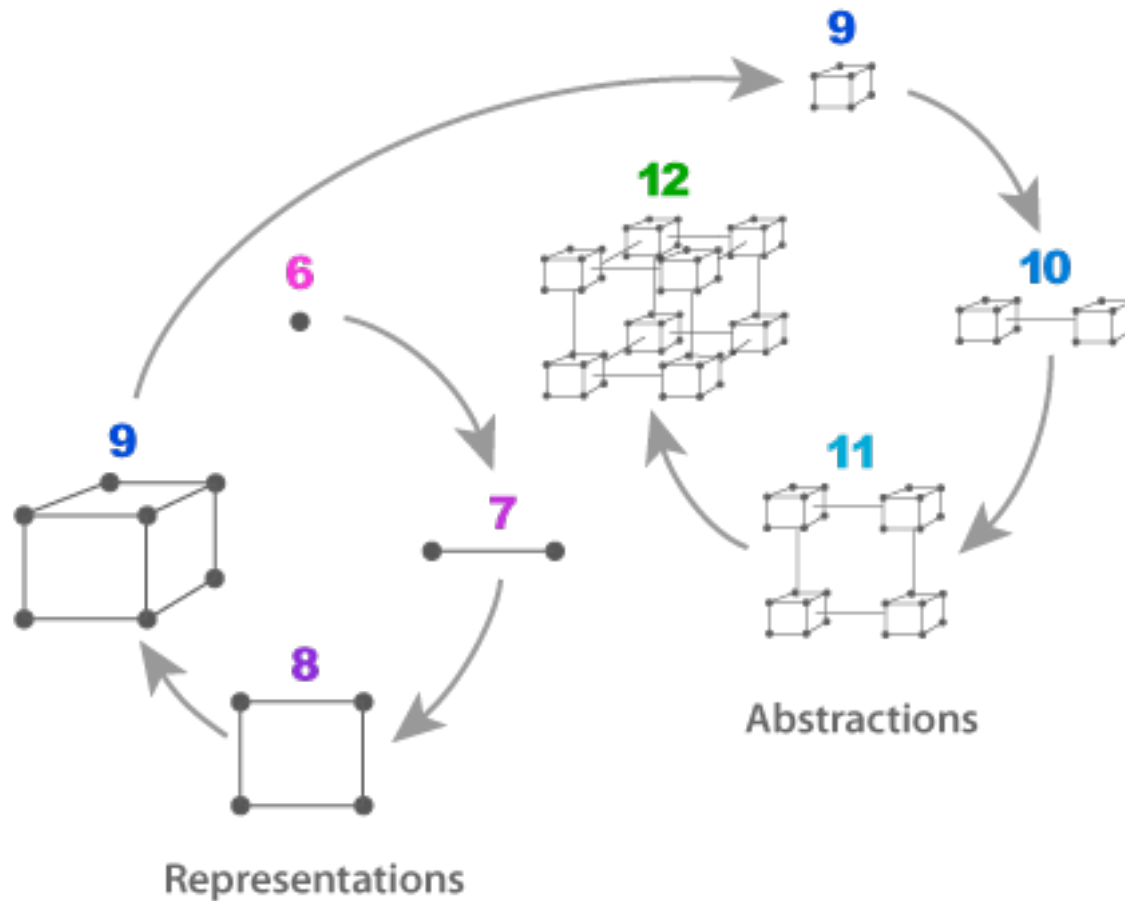
Abstractions

Lectical level	Fischer category	Age of onset	Education
6	Single Representation	21 months	pre-K
7	Representational Mapping	4-5 years	0-K
8	Representational Systems	7-8 years	1-2
9	Single Abstraction	10-11 years	4-5
10	Abstract Mapping	14-15 years	8-9
11	Abstract Systems	22+ years	15-16
12	Single Principles	26+ years	Ph.D.+

Raw interview data
(unanalyzed protocols)

lectical (structural)
analysis

content
analysis

organize protocols along
the dynamic skill scale

identify themes
within protocols

combine to
produce

Examples of reasoning about each
theme, arranged along the skill scale

Descriptions of reasoning
about each theme at each level

employ
inductive
procedure
to produce

Potential uses for lectical assessments?

- Determine developmentally appropriate learning objectives for individuals;

- Evaluate curricula designed to improve thinking skills;

- Design customized learning recommendations;

- Research changes in learning across different domains, sub-domains and themes;

- Construct "<u>heat maps</u>" to guide classroom activities.

Developmental Maiuetics
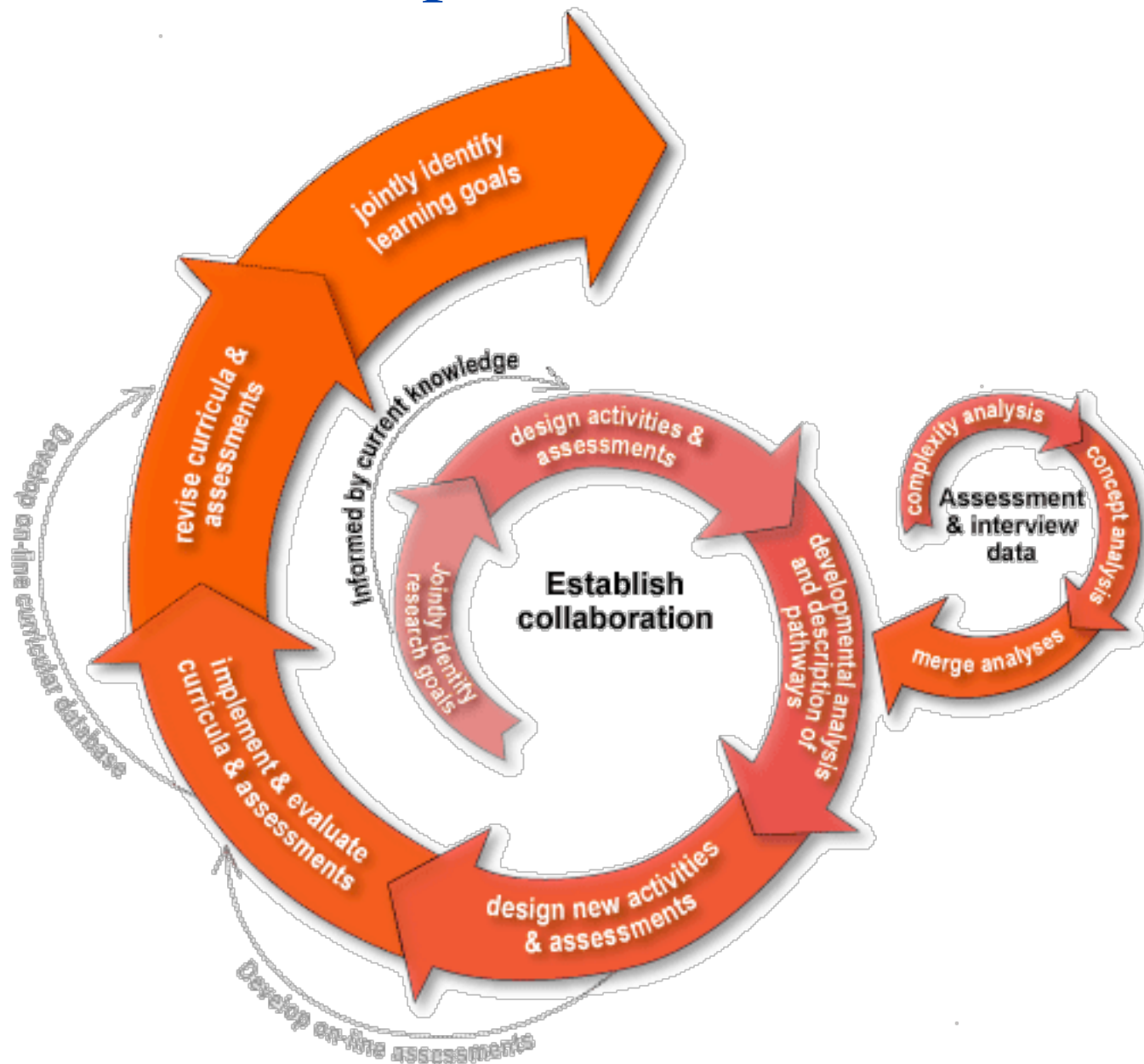
Lectical Assessments:
Physics of Energy

POE001: QUESTION 1

The image shows a hand pressing down on a ball, which is on top of a spring. ▶

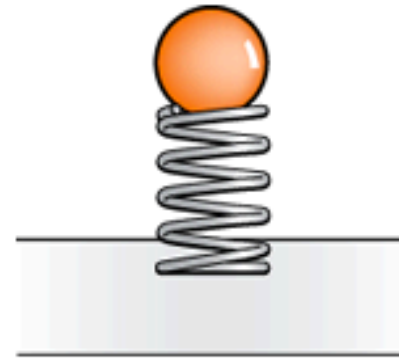Describe what is happening to the energy of the ball as it is pressed into the spring? *Explain your answer.*

0

What would happen to the energy of the ball if the hand moved away? *Explain your answer.*
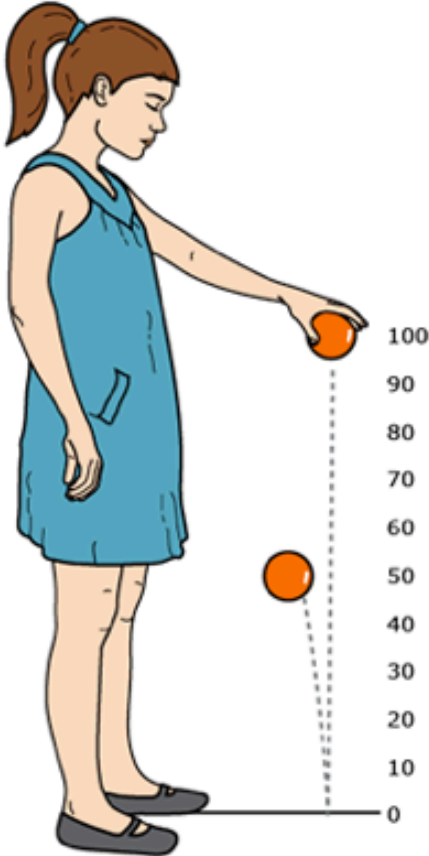
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POE001: QUESTION 2

The image shows a ball sitting on top of a spring. ▶

Describe what is happening to the energy of the ball as it sits on top of the spring. Explain your answer.

0

POE001: QUESTION 3

The image shows a ball that is dropped from a height of 100 centimeters, and bounces back to a height of 50 centimeters. ▶
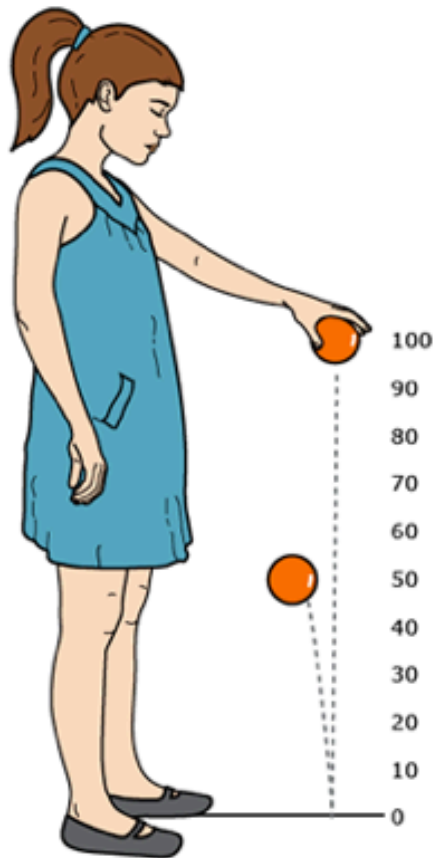

Describe what is happening to the energy of the ball **as it falls to the floor**. Explain your answer.

POE001: QUESTION 4

The image shows a ball that is dropped from a height of 100 centimeters, and bounces back to a height of 50 centimeters. ▶

Describe what is happening to the energy of the ball **as it hits the floor**. Explain your answer.

100
90
80
70
60
50
40
30
20
10
0

POE001: QUESTION 5

The image shows a ball that is dropped from a height of 100 centimeters, and bounces back to a height of 50 centimeters. ▶
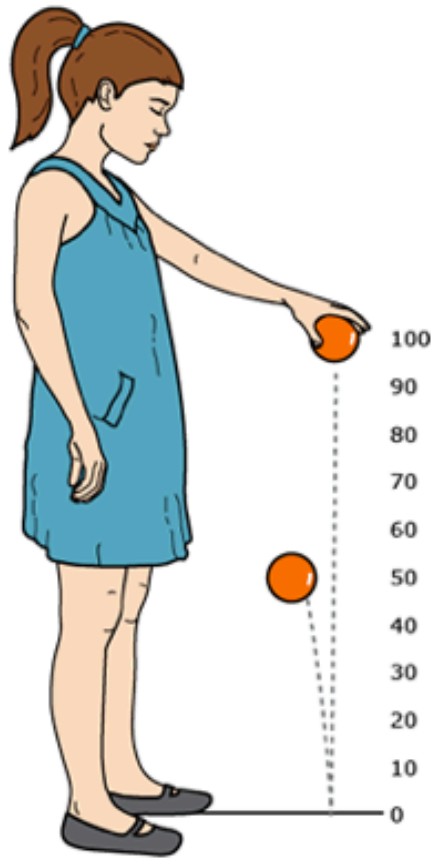
Describe what is happening to the energy of the ball right **after it hits the floor**. Explain your answer.

100
90
80
70
60
50
40
30
20
10
0

0

Lectical Assessments: Developmental Pedagogy

"I expect you all to be independent, innovative, critical thinkers who will do exactly as I say!"

CMMAP Teaching Fellows

- Luke Van Roekel-CSU (EV 431-07): Drossman
- Jim Benedict-CSU (EV 431-08): Drossman
- Kate Thayer-Calder-CSU (EV 128-08): Leonard
- Kelley Wells-CSU (EV 431-09): Drossman
- Rachel McCrary-CSU (EV128-09): Taber
- Anna Harper-CSU (EV 128-09): Fricke
- Kate Thayer-Calder-CSU (EV 128-10):Taber
- Ian Baker-CSU (EV 211-10): Drossman
- Erica McGrath-Spangler-CSU (EV431-10): Drossman
- Mari Titcombe-NCAR (EV 211-11): Drossman
- Kat Huybers-UW (EV 128-11): Kummel
- Zoe Harrold-UW (EV 211-12): Janke
- Spruce Schoenmann-UW (EV 128-12): Kummel
- Twila Moon-UW (EV 128-13): Taber
- Aaron Pina-CSU (EV 211-13): Drossman
- Kristin Poinar-UW (EV 128-14): Kummel
- Alice DuVivier-NCAR (EV 431-14): Drossman

Hypothesis 1

A constructivist-motivated approach to mentoring effectively allows graduate fellows to learn about constructivist-motivated pedagogy. (54)

   a) Fellows' views about effective teaching significantly changed as a result of the teaching fellowship. (21)

   b) Learning to teach in a real college-level course was a constructivist-motivated approach. (22)

   c) Appropriate time for reflecting on their preconceptions about their teaching allowed the Fellows to gain a deeper understanding of pedagogy. (11)

Hypothesis 2

Graduate fellows learn to formulate hypotheses related to the scholarship of teaching and learning (SOTL) by reflecting on their development and use of pedagogical innovations. (69)

a) A student-centered approach motivates learning by adapting pedagogy to their learning needs and providing appropriate time for reflection. (36)

b) The use of real world applications promotes undergraduate student learning. (14)

c) Constructivist-motivated pedagogy requires thoughtful consideration of the dialectic between process and content. (19)

Lectical Developmental Pedagogy Assessment (LDPA, Pt. 1)

As an educational consultant, you have been asked to aid in the development of an effective year-long developmental program. There are two constraints: The program must be (1) informed by developmental theory and (2) include curricula and assessments.

Name two skills that your curriculum recommendations will focus upon. Explain why you chose these skills. Then, name three primary sources you will consult as you craft your recommendations. Explain why you selected these sources.

With reference to the sources named in your response to question 2, describe how the skills you have selected are likely to develop over the course of a year. Refer to the mechanisms of learning (how it happens) and the specific changes that are likely to take place in student skills or understanding.

Lectical Developmental Pedagogy Assessment (LDPA, Pt. 2)

For the first targeted skill, describe an instructional activity that would be likely to support the kind of change you described in response to question 2. Explain how this activity relates to the mechanisms of learning described in question 2.

For the second targeted skill, describe an instructional activity that would be likely to support the kind of change you described in response to question 2. Explain how this activity relates to the mechanisms of learning described in question 2.

For one of your targeted skills, describe two ways in which instructors can simultaneously support student learning and assess the learning that takes place over the course of the year. Explain why they are likely to be effective. Assume that there are no available off-the-shelf assessments.

Mentoring Program Assessment

	Interior	**Exterior**
Individual	**What did I learn about pedagogy?** **Did my pedagogical knowledge help me teach more effectively?**	**What observable evidence exists for students' learning?** **What observable evidence exists for teachers' learning?**
Collective	**Did the mentoring relationship enhance my teaching?**	**Do 'classroom experiments' help mentors learn to teach?** **Do 'classroom experiments' hinder students' learning?**

Lectical Assessments: Reflective Judgement (Pt. 1)

Psychologists disagree about the impact of violent television on children. One group argues that the evidence suggests that television violence causes children to engage in violent behavior. Another group argues that the evidence suggests that television violence prepares children for the realities of adult life, much like fairy tales did before the invention of television.

Lectical Assessments: Reflective Judgement (Pt. 2)

The questions that respondents answer to complete the LRJA include:

• How is it possible that experts can come to such different conclusions?

• What is it about problems like this one that makes the truth so difficult to find?

• How would you go about gathering the information you would need to form an opinion on a problem like this one? What kind of information sources would you consider? Why?

• How would you go about evaluating the quality of information you obtain from different sources? Why? How do you know when you have the "right" information?

• Can you be certain that your conclusions are correct? Why or why not?

• People often use terms like reality, truth, or facts when responding to this dilemma. What do these terms mean to you? (Make sure you define and explain each term.)

Summary

•New learning models can provide very useful insights for assessment!

•Lectical methods, though initially costly, provide one effective way to develop assessments.

• Assessments should provoke the way we think about teaching effectiveness and provide a method for testing hypotheses about teaching effectiveness.

•Lectical assessments measure the development of skills and not native intelligence.

•There is accumulating evidence that lectical measurements provide a domain-independent ruler of cognitive development along numerous skill lines.

Acknowledgements

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- Amy Briggs (Lectica manager)
- Colorado College Dean's Office ($)