

# Misconceptions & PL DESIGN



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# LAST TIME: PIAGET'S STAGE THEORY

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0-2

Sensorimotor

2-7

Pre-Operational

7-11

Concrete Operational

11-

Abstract Operational

32% OF ADULTS



*New Ideas Always Emerge from Old Ones*

Jean Piaget's **Constructivism**



*“Students do not just lack knowledge; they think differently than experts.”*

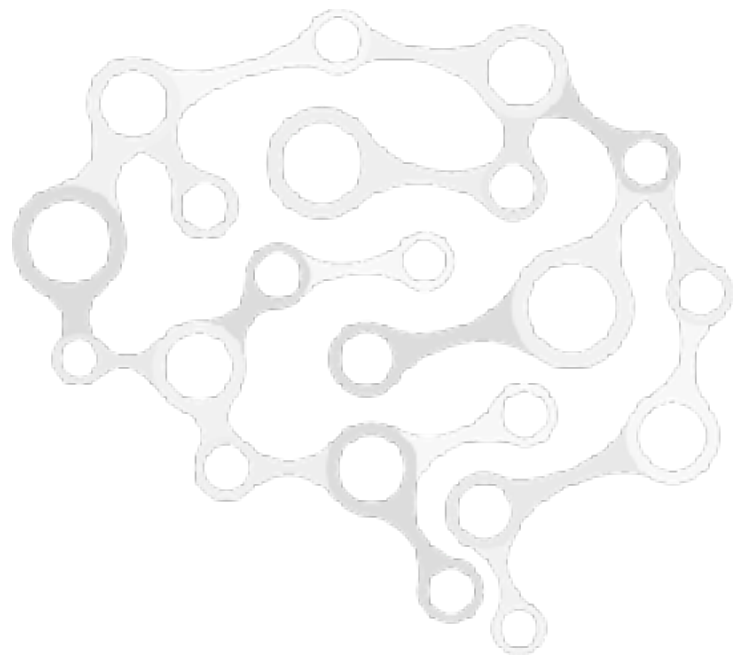
Andrea diSessa

A History of Conceptual Change Research

# PRIOR KNOWLEDGE (PRECONCEPTIONS)

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*Mental Model*



*Missing*

**Needs  
Adding / Gap Filling**



*Wrong*

*Misconception*

**Needs  
Conceptual Change**



*Correct*

# "CONCEPTUAL CHANGE" RESEARCH

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## Coherence Perspective

Strongly  
Integrated

Paradigm Shift /  
Gestalt Switch /  
All at Once /  
Revolution /  
Before & After

The Structure of Scientific  
Revolutions



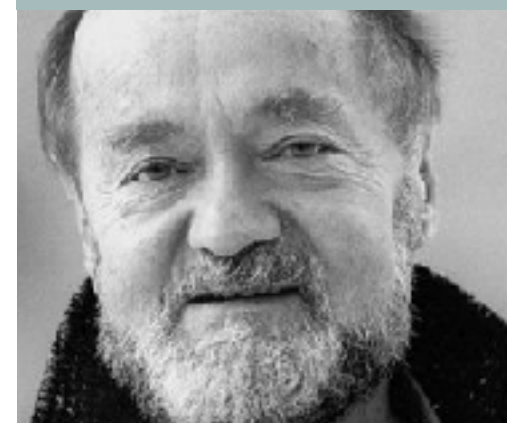
Thomas Kuhn

## Fragmentation Perspective

Quasi Independent  
Elements

Gradual Change /  
Moving Picture /  
Process-Based

Stephen Toulmin



Human Understanding

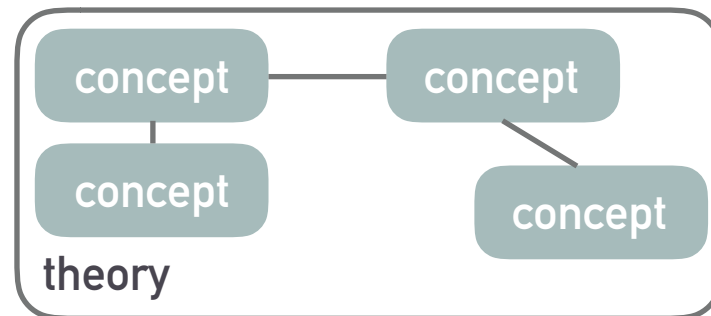


# “CONCEPTUAL CHANGE” RESEARCH

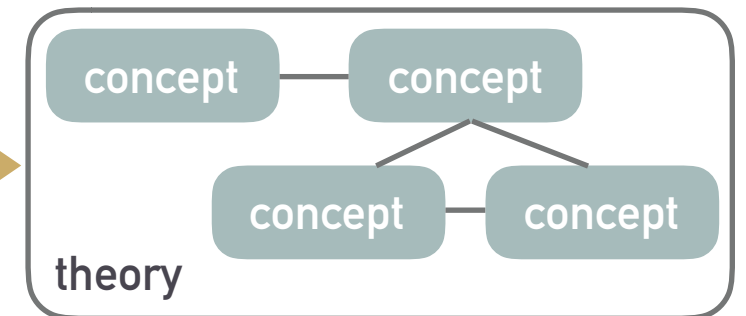
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Theory Change  
(Coherence)

naive



expert / scientific

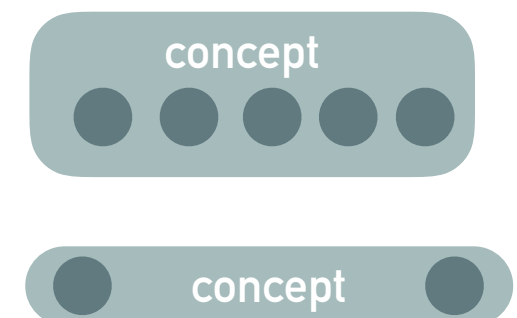
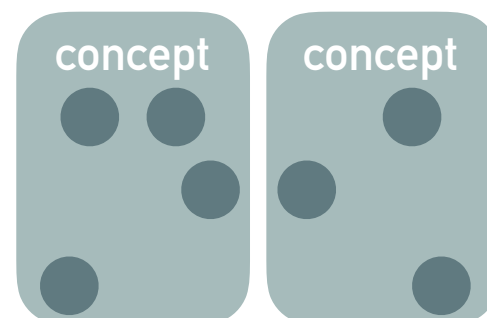


facet  
Minstrell

p-prim  
diSessa

*phenomenological  
primitive*

Knowledge in Pieces  
(Fragmentation)



# SMITH ET AL.'S DEFINITION

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misconception:  
flaw in mental model

Misconception:

“student conception that produces a systematic pattern of errors”

error:  
flaw in program



# MISCONCEPTION RESEARCH

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- mid 1970 - early 1990
  - **documented** 100s of misconceptions
  - physics, biology, math
  - “tiny specks of matter don’t weigh anything”
  - “heat and cold are different things”

# WHY CATALOGUE MISCONCEPTIONS?

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- To improve learning (facilitate conceptual change)
- To develop assessments
  - Tew's FCS1
  - SRI's PACT
  - Project Quantum (Simon Peyton Jones)
  - Bebras
- To develop concept inventories
  - Programming Fundamentals (Goldman et al.)
  - Introductory Programming (Caceffo et al.)
  - Algorithms & Data Structures (Danielsiek et al.)

# WHY CATALOGUE MISCONCEPTIONS?

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To improve programming language designs?

*unlike physics, chemistry, biology,*

*PLs are designed by humans*

# HOW TO FIND MISCONCEPTIONS?

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## Kinds of Student Assessments Tew & Guzdial

### Errors in Descriptions of Concepts

Interviews, Think-Alouds, Concept Maps

definitional questions

### Errors in Program Interpretation

Visual Program Simulation

tracing questions

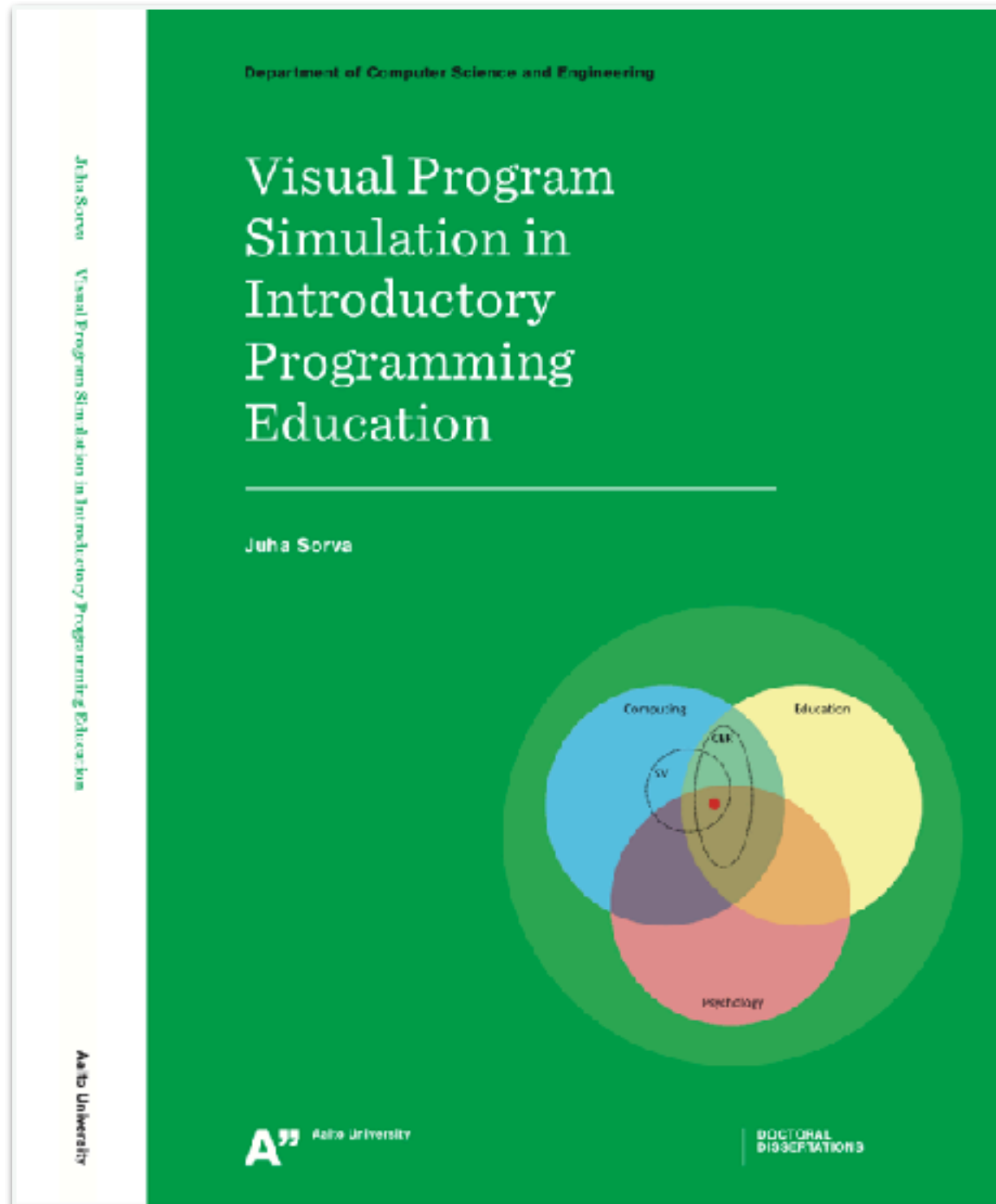
### Errors in Program Creation

Code

code completion questions

# SORVA'S LIST

.....



# SORVA'S LIST: 162

*“left out* issues that appear to be highly **language-specific** or **tool-specific** as well as **trivial mistakes** concerning notation such as mistaking an operator for another.”

.....

- General: 8
- VarAssign: 14
- Control: 15
- Calls: 16
- Rec: 8
- Refs: 17
- ObjClass: 20
- ObjState: 25
- Methods: 15
- OtherOOP: 11
- Misc: 13

# SORVA'S LIST: EXAMPLE MISCONCEPTION

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## #9 VarAssign

A variable can hold multiple values at a time /  
'remembers' old values.





# Misconceptions in programming

*Programming Fundamentals II*

*OOP in Java*

*2nd semester, USI*

# HAUSWIRTH'S LIST: HOW WE FOUND MISCONCEPTIONS



Exam Solutions

Reading Recalls

Mastery Checks

definitional questions

Descriptions of Concepts

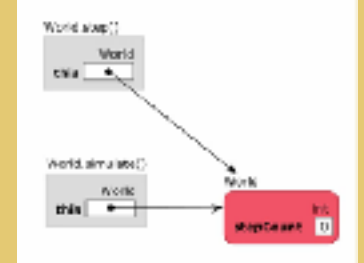
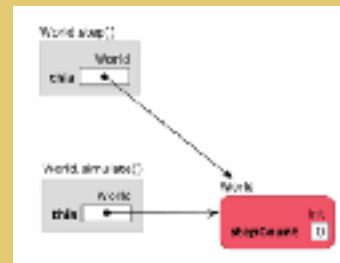
Explain...  
Contrast...

Summarize...

Explain...  
Contrast...

tracing questions

Program Interpretation



code completion questions

Program Creation

Implement...

Implement...

# HAUSWIRTH'S LIST

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## ➤ How we Organised: 6 Themes / 51 Topics / 238 Skills

### Java API

Learn to use the key classes in the Java API.



### Algorithms and Data Structures

Learn to implement algorithms and data structures in Java.



### Java Language

Learn to properly use the features of the Java language.



### Design Concepts

Learn to properly design object-oriented programs.



### Development

Learn basic software development techniques.



### Representations

Learn to map between code and diagrams.



# HAUSWIRTH'S LIST: 63

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## Java Language

- Classes & Objects: 7
- Method Invocation: 7
- Variables: 8
- Literals: 8
- Types: 11
- Operators: 7
- Method Implementation: 9
- References: 5
- Array Basics: 6
- Arrays: 5
- Inheritance: 3
- Use Generics: 2
- Packages: 2
- Exception Handling: 2
- Auto Boxing: 1



## Representations

- Sequence Diagrams: 1
- Control Flow: 1
- Stack and Heap: 3
- Call Trees: 1



## Algorithms and Data Structures

- Conditional Computation: 4
- Iterative Computation: 1
- Implement Lists, Sets, and Maps: 1



## Development

- Debugging: 1
- Javadoc: 2



## Java API

- Use Sets and Maps: 1
- Use Lists: 1



## Design Concepts

- Immutability: 1

# HAUSWIRTH'S LIST: EXAMPLE MISCONCEPTION

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Classes vs. Objects

**Set of class members can change at runtime**

*One can add, remove, or rename members (fields, methods) of a class at runtime.*

# HAUSWIRTH'S LIST: EXAMPLE MISCONCEPTION



Misconception

## Set of class members can change at runtime

One can add, remove, or rename members (fields, methods) of a class at runtime.

Correction

## Correction

Wrong. The set of members of a class is a defining characteristic of the class type. The class (i.e., type) cannot change at runtime, because Java is a statically typed language.

Related Topics



### Classes vs. Objects

Java Language



#### Explain difference between objects and classes

Explain in which ways objects and classes are different.



### Method Implementation

Java Language



#### Write a method skeleton

Given the return type and parameter types, write the skeleton (header and body with just a return statement) of a method. Explain.



#### Write a constructor skeleton

Given the parameter types, write the skeleton (header and empty body) of a constructor. Explain.



### Variables

Java Language



#### Declare an instance variable

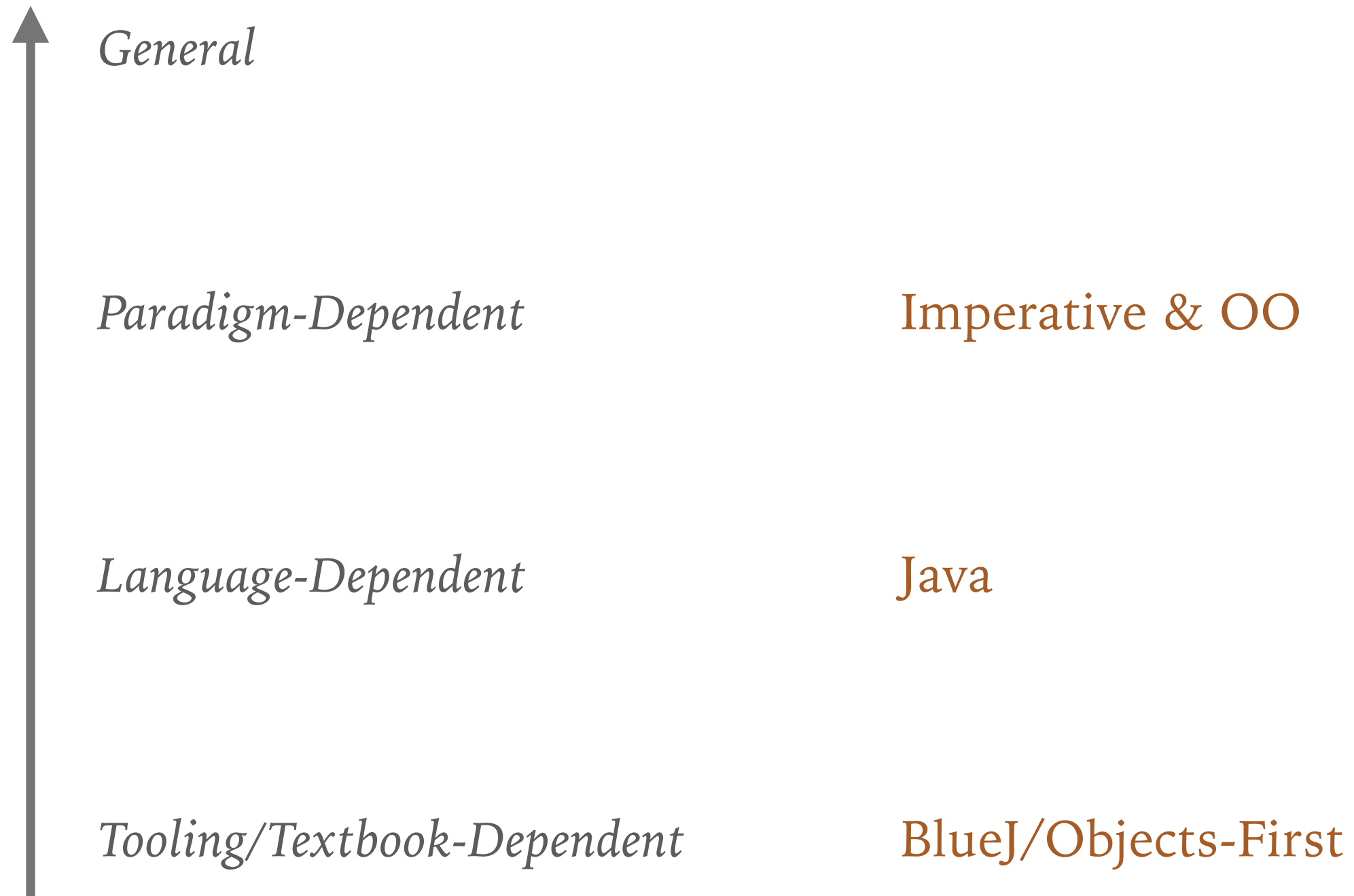
Given the source code of a class, add a declaration of an instance variable with a given name and type, and initialize its value in the constructor. Explain.

Assessment  
Items

Study Tasks

# GENERALITY OF MISCONCEPTIONS

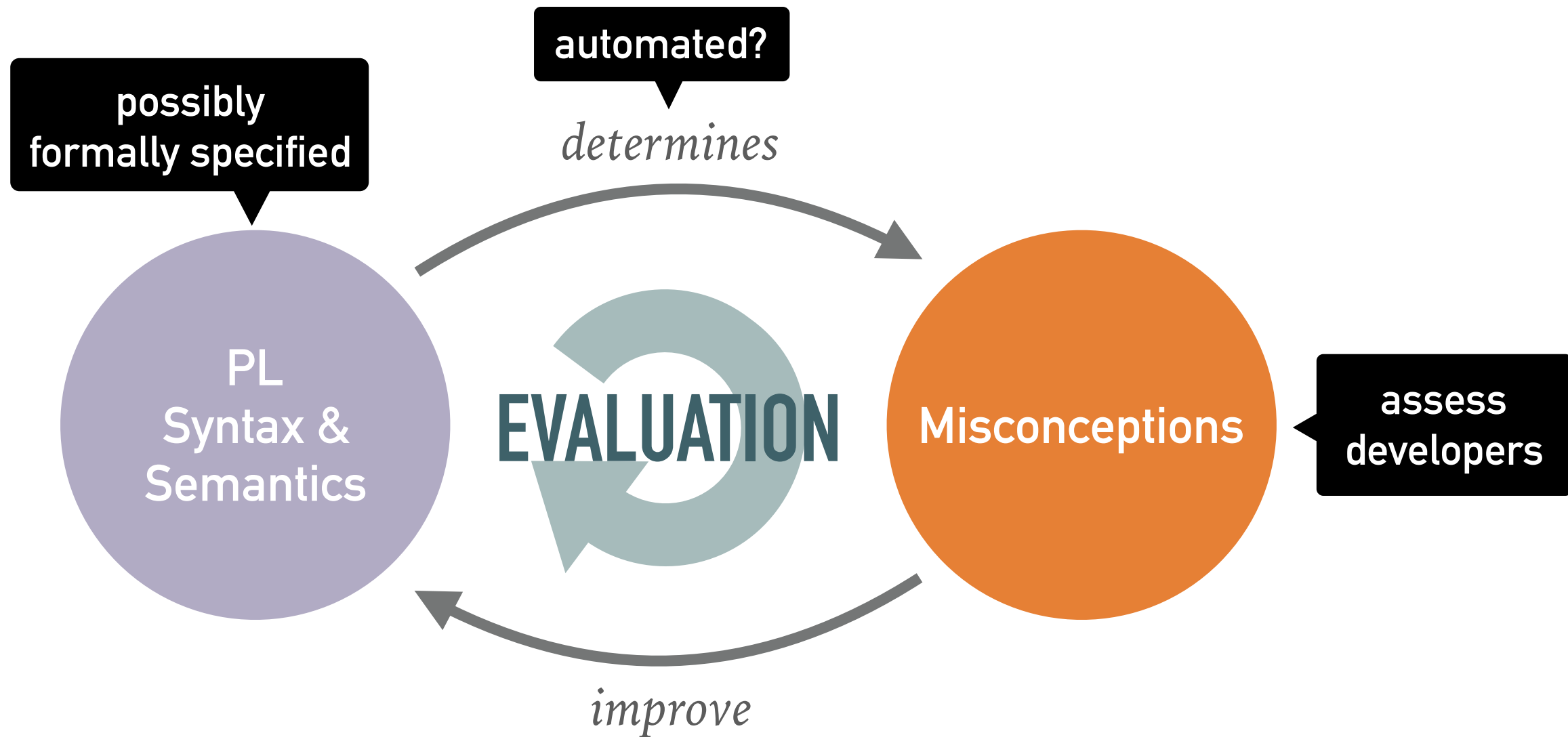
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# MISCONCEPTIONS VS. PL DESIGN

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# WEAKNESSES IN MISCONCEPTION RESEARCH

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- Only *negative* contributions of prior knowledge
  - “naive ideas are simply wrong”
- Depth of misconceptions uncalibrated

# QUESTIONS IN MISCONCEPTION RESEARCH

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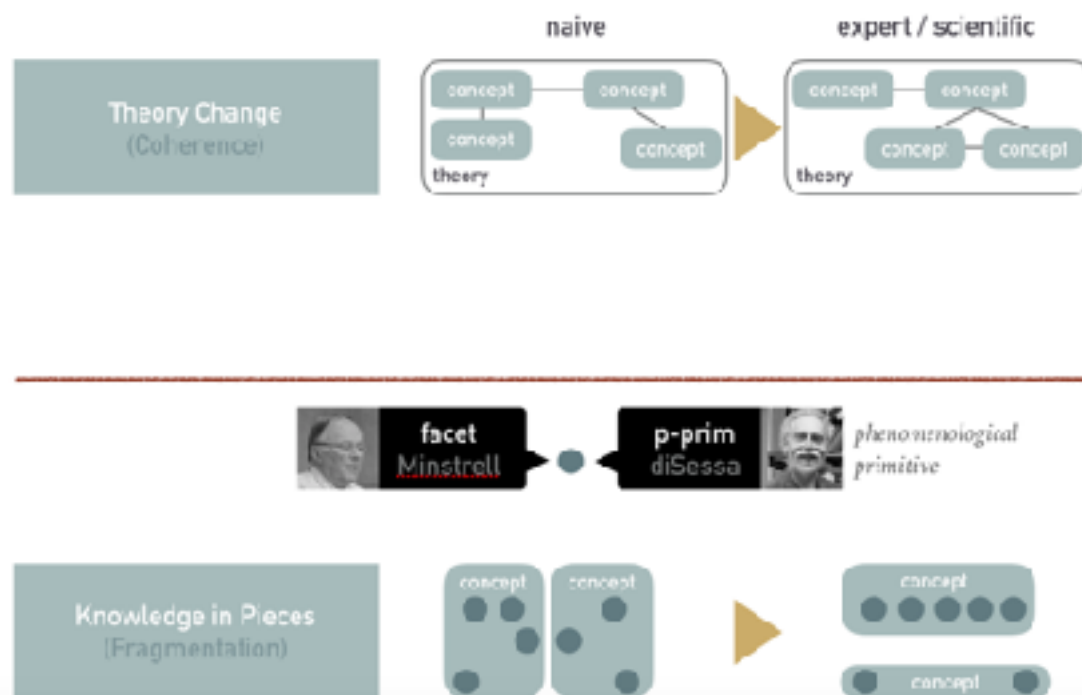
- What is a concept?
- Can we decompose concepts into pieces?
- Can we fit concepts into coherent wholes?
- How do genuine concepts develop out of naive ones?

# QUESTIONS ON MISCONCEPTIONS & PL

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- To what degree do PL learners have preconceptions?
  - in physics, direct experience  $\Rightarrow$  preconceptions
- What are the (correct) concepts in PL?
  - Just the syntactic/semantic constructs?
    - Recursion??
  - Conceptual vs. procedural competencies?
- What are misconceptions in PL?
  - Absence/“negation” of syntactic/semantic constructs?

## "CONCEPTUAL CHANGE" RESEARCH



## HAUSWIRTH'S LIST: HOW WE FOUND MISCONCEPTIONS



	Exam Solutions	Reading Recalls	Mastery Checks
definitional questions	Explain... Contrast...	Summarize...	Explain... Contrast...
Descriptions of Concepts			
tracing questions			
Program Interpretation			
code completion questions	Implement...		Implement...
Program Creation			

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## MISCONCEPTIONS VS. PL DESIGN

