Designing Scenario-Based Assessment Items Using an Evidence-Centered Design Framework

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Workshop Overview - Content

- Background
  - Scenario-Based Assessment
  - Storyboarding
  - Evidence-Centered Assessment Design
  - Assessment Design Patterns
- Assessment Design Patterns
  - Select & Specify a Topic for a Scenario-Based Task
  - Write Scenes for a Scenario-Based Task
  - Fine Tune Item Ideas to Embed in Scenario-Based Tasks
- Each section of content followed by hands-on activity

Workshop Overview - Logistics

- Folder contains a detailed agenda, the presentation slide deck, and resources for supporting the hands-on activities
- Activity worksheets will be passed out prior to each activity
- Use large notepads and markers to record group ideas during the activities; report on activity outcomes and ideas
- Two 10-minute breaks scheduled

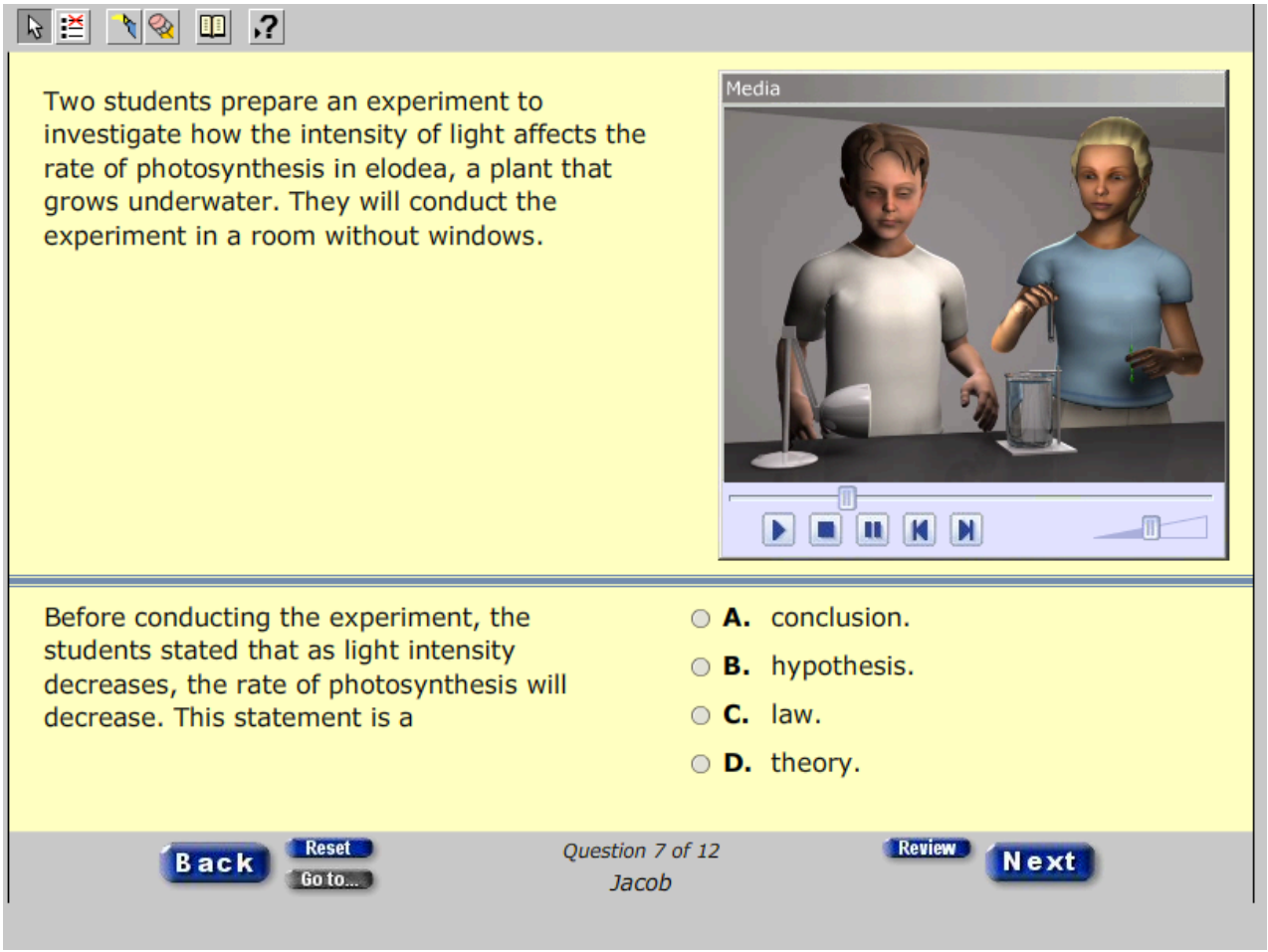
Scenario-Based Assessment

- Multiple scenes built around common context or situation
- One or more items embedded in each scene that elicit responses
- Often targets both content knowledge and inquiry skills
- Can include static or dynamic knowledge representations (e.g., tables, charts, animations, simulations)

Scenario-Based Assessment

Minnesota State Comprehensive Science Assessment II – High School

Example Scenario-based task, Photosynthesis



Scenario-Based Assessment

Minnesota State Comprehensive Science Assessment II – High School

Example Scenario-based task, Photosynthesis

A sprig of elodea is placed upside down in a test tube filled with a solution. The test tube is placed in a large beaker full of water, which serves as a water bath. Photosynthesis will produce bubbles of gas. The bubbles will eventually come out of the stem and rise to the top of the test tube.

The students will use a light source during their experiment. The light source will be moved closer to and farther away from the plant to change the intensity of light it receives. The rate of photosynthesis will be measured by counting how many bubbles come out of the stem in 1 minute.

Which of these variables would be most important to keep constant during the experiment?

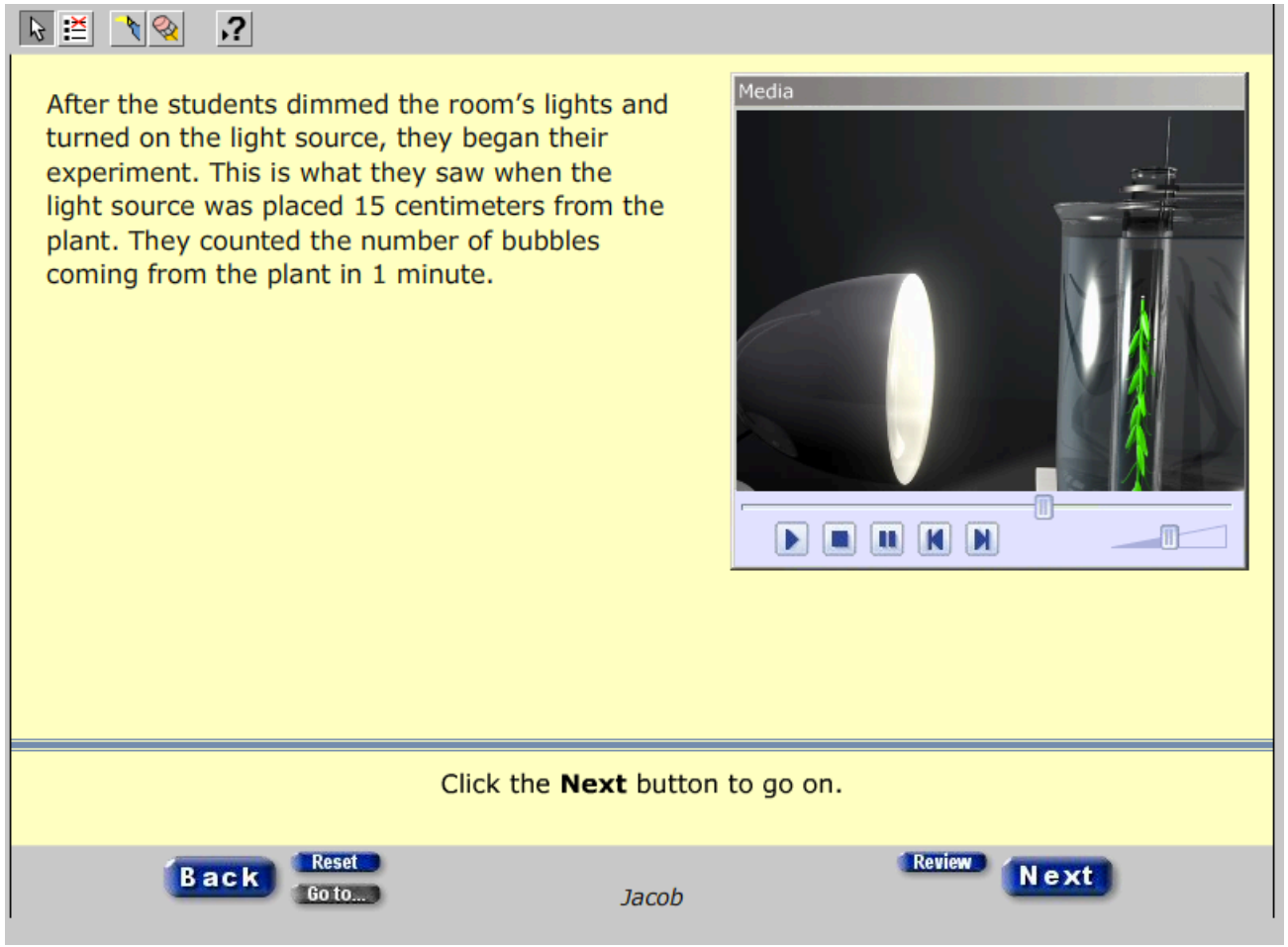
- **A.** Number of bubbles produced by the elodea
- **B.** Distance of the light from the test tube
- **C.** Temperature of the solution in the test tube
- **D.** Time of day the experiment is conducted

Back Reset Go to... Question 8 of 12 Jacob Review Next

Scenario-Based Assessment

Minnesota State Comprehensive Science Assessment II – High School

Example Scenario-based task, Photosynthesis



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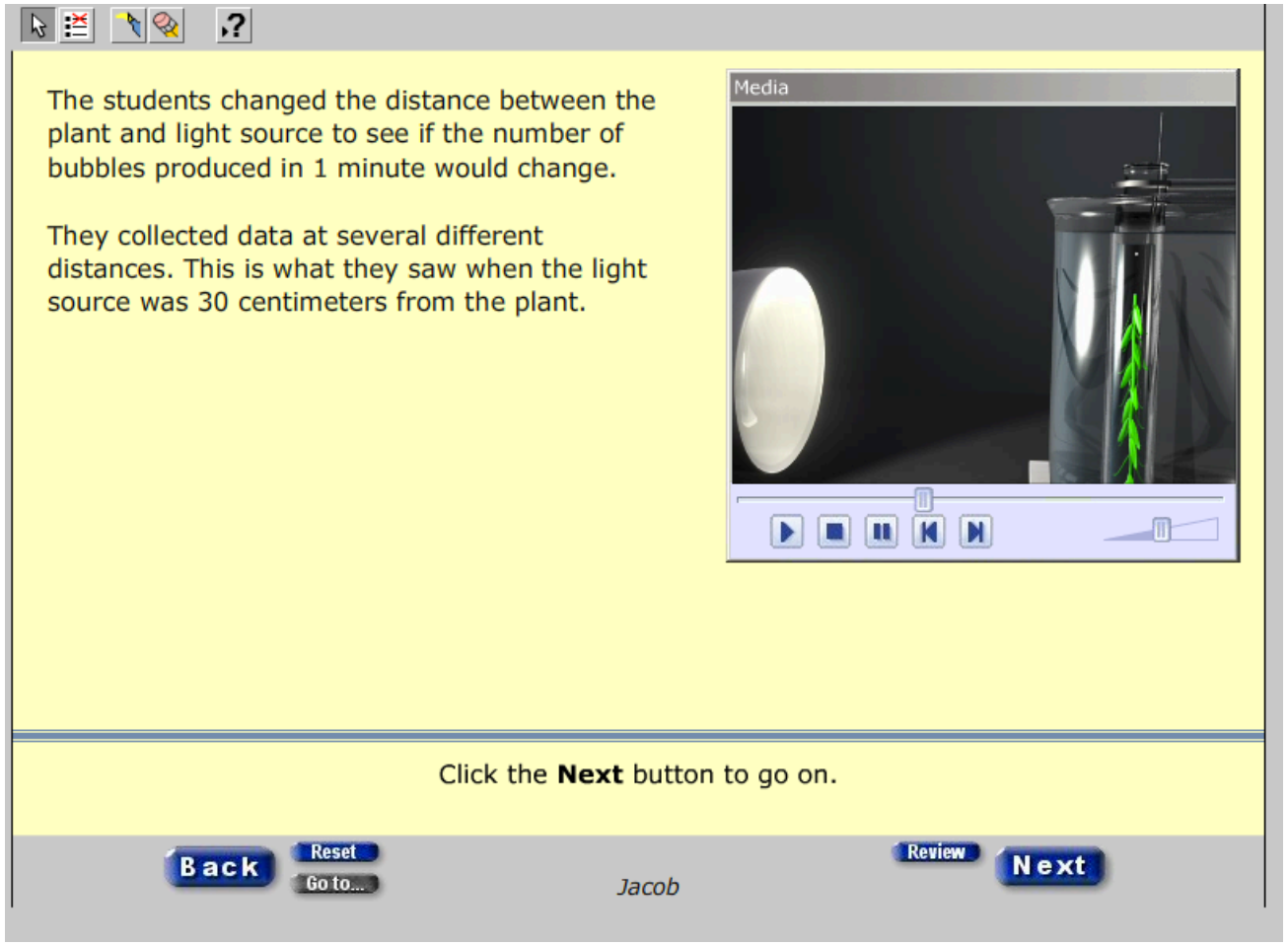

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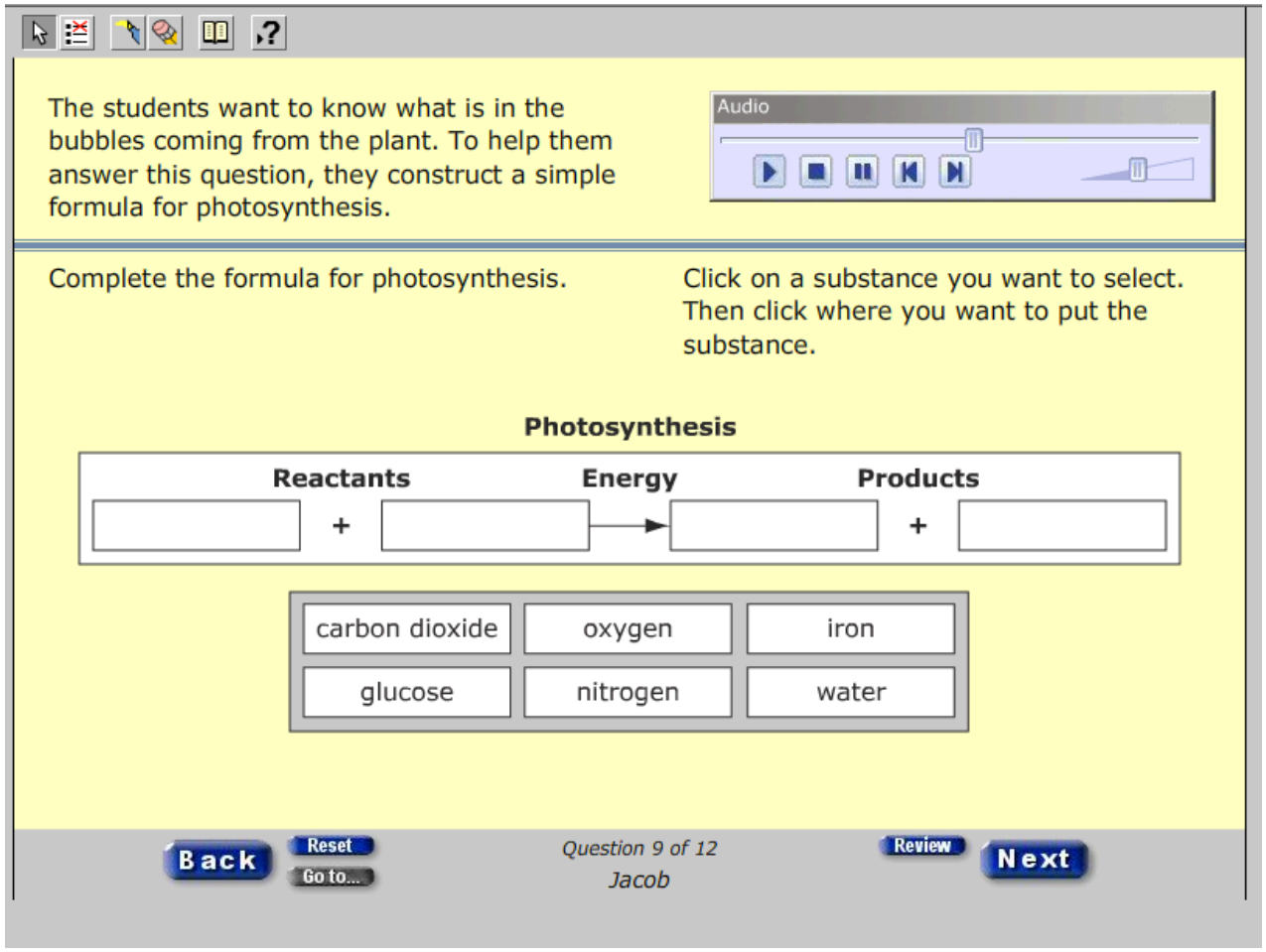


Storyboarding & Scenario-based Assessment

- Supports development of scenario-based tasks
- Precursor to scenarios and embedded items
- Help frame context in which (standards-aligned) items can be embedded
- Describe series of events or natural phenomena
- Organized into 4-5 scenes
- Scenes contain script text, art description

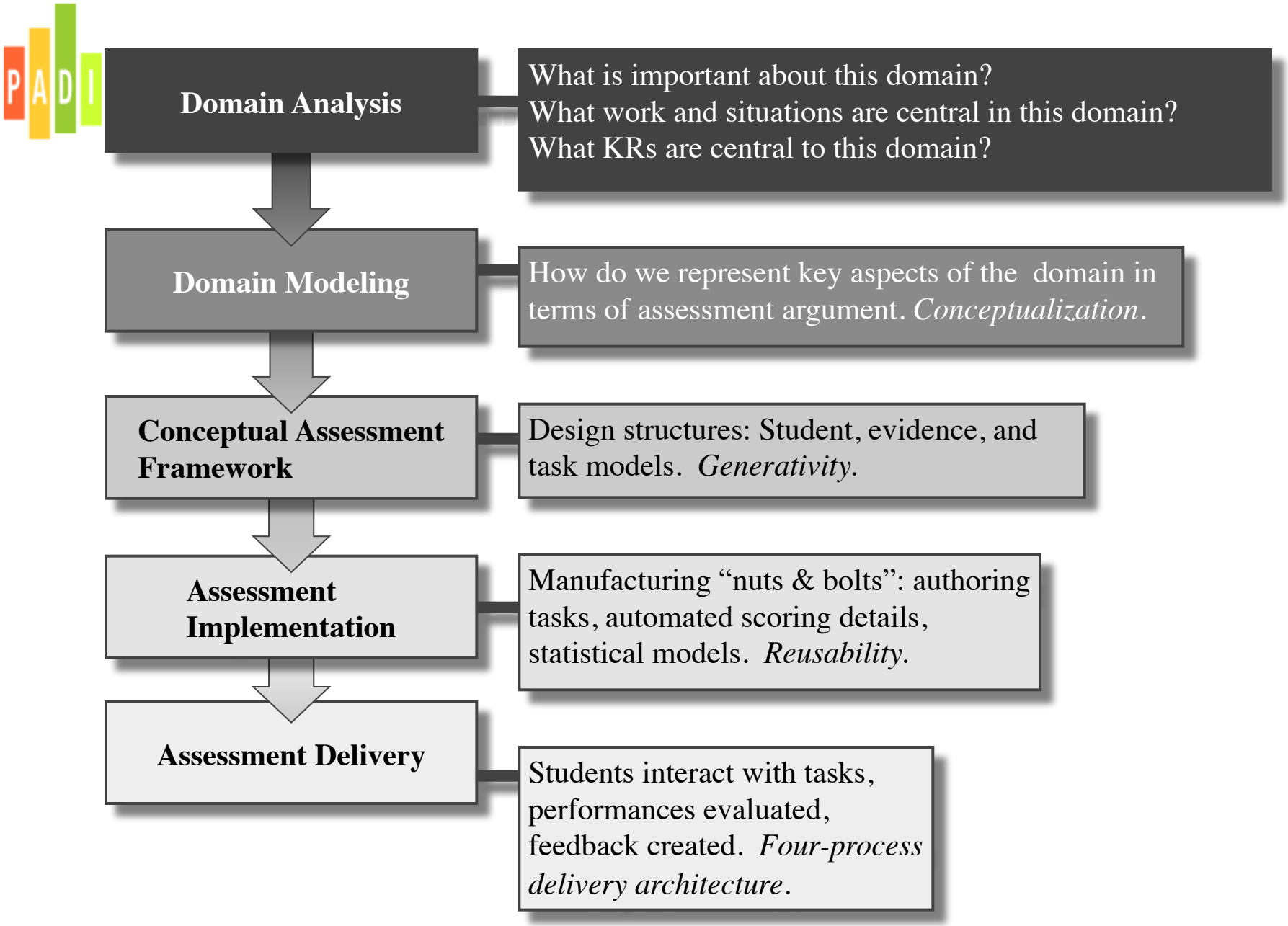
Evidence-Centered Assessment Design

- Mislevy, Steinberg, & Almond at ETS in late 1990s
- Cisco / ETS / University of Maryland
- Principled Assessment Design in Inquiry (PADI) project
  - SRI, University of Maryland, UC Berkeley, FOSS, BioKIDS
  - National Science Foundation
- ECD for Large-Scale State Assessments
  - SRI, University of Maryland, Pearson, Haney Research & Evaluation, Minnesota Department of Education
  - National Science Foundation
- Principled Science Assmt Design for Students in Special Ed
  - SRI, University of Maryland, Pearson, CAST
  - Institute of Education Sciences

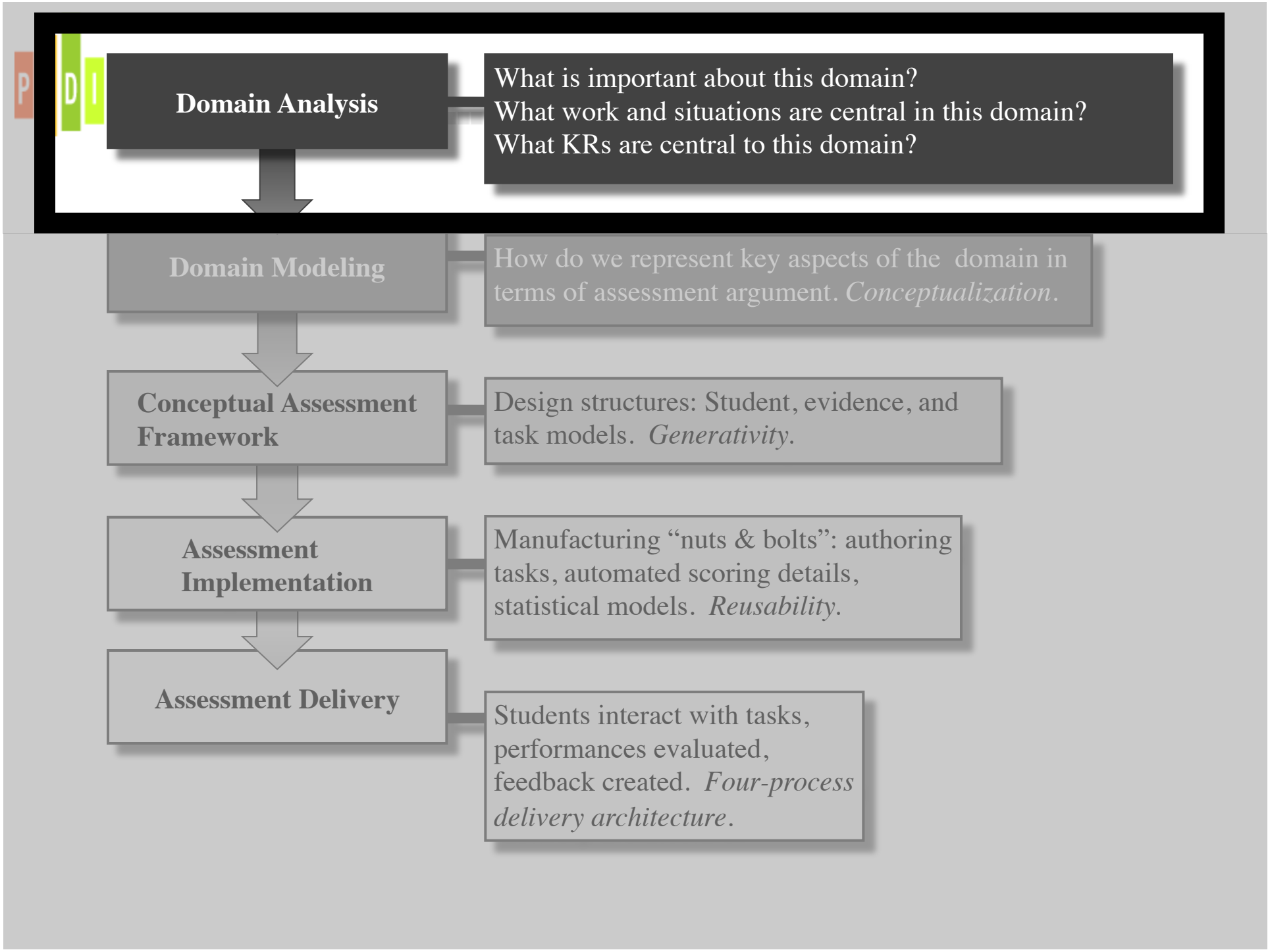
Evidence-Centered Assessment Design

Formal, multiple-layered framework from Messick's (1994) guiding questions:

- What complex of knowledge, skills, or other attributes should be assessed?
- What behaviors or performances should reveal those constructs?
- What tasks or situations should elicit those behaviors?



- From Mislevy & Riconscente, 2006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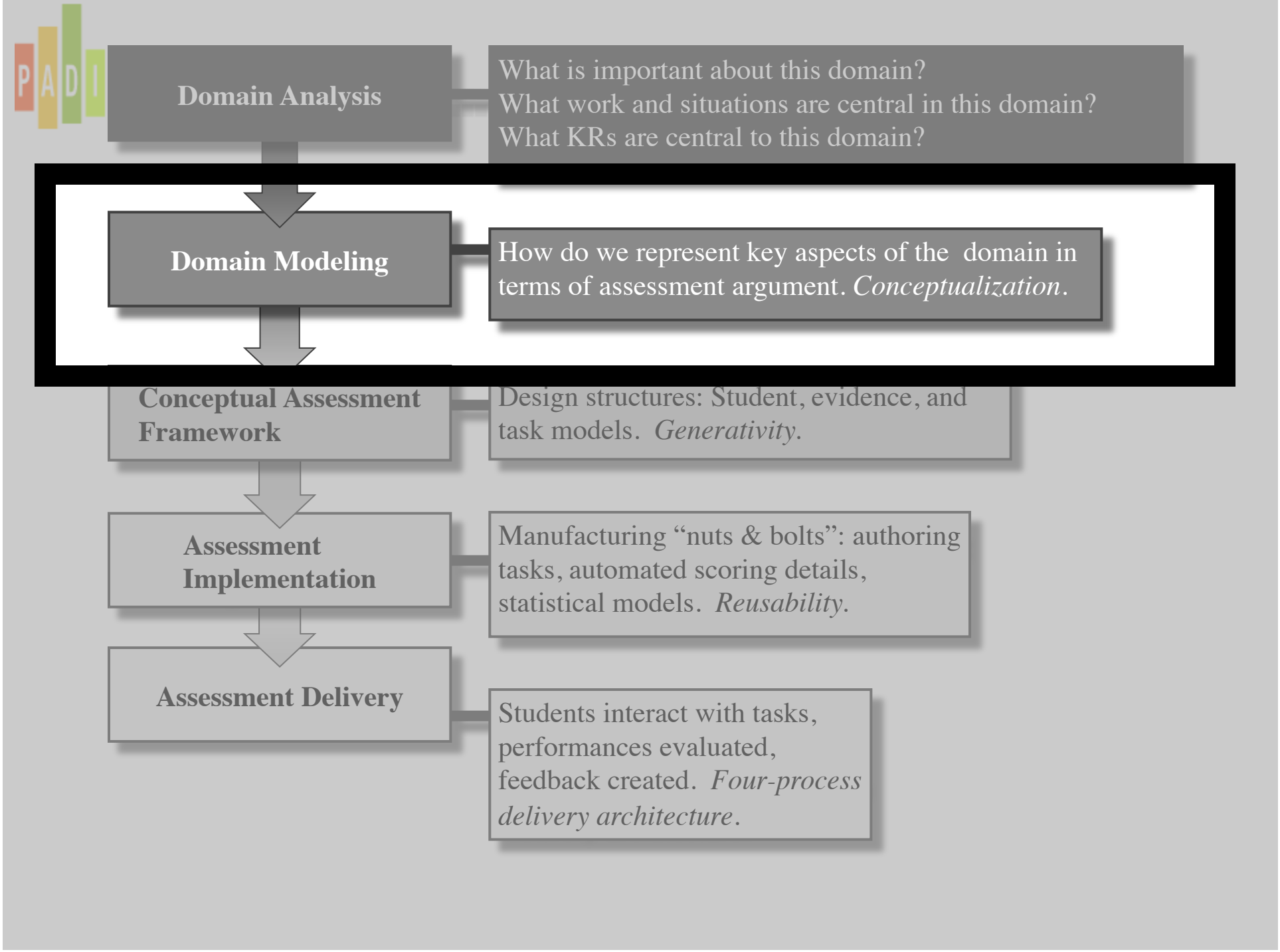
D
I
Domain Analysis
What is important about this domain?
What work and situations are central in this domain?
What KRs are central to this domain?
Domain Modeling
How do we represent key aspects of the domain in terms of assessment argument. Conceptualization.
Conceptual Assessment Framework
Design structures: Student, evidence, and task models. Generativity.
Assessment Implementation
Manufacturing "nuts & bolts": authoring tasks, automated scoring details, statistical models. Reusability.
Assessment Delivery
Students interact with tasks, performances evaluated, feedback created. Four-process delivery architecture.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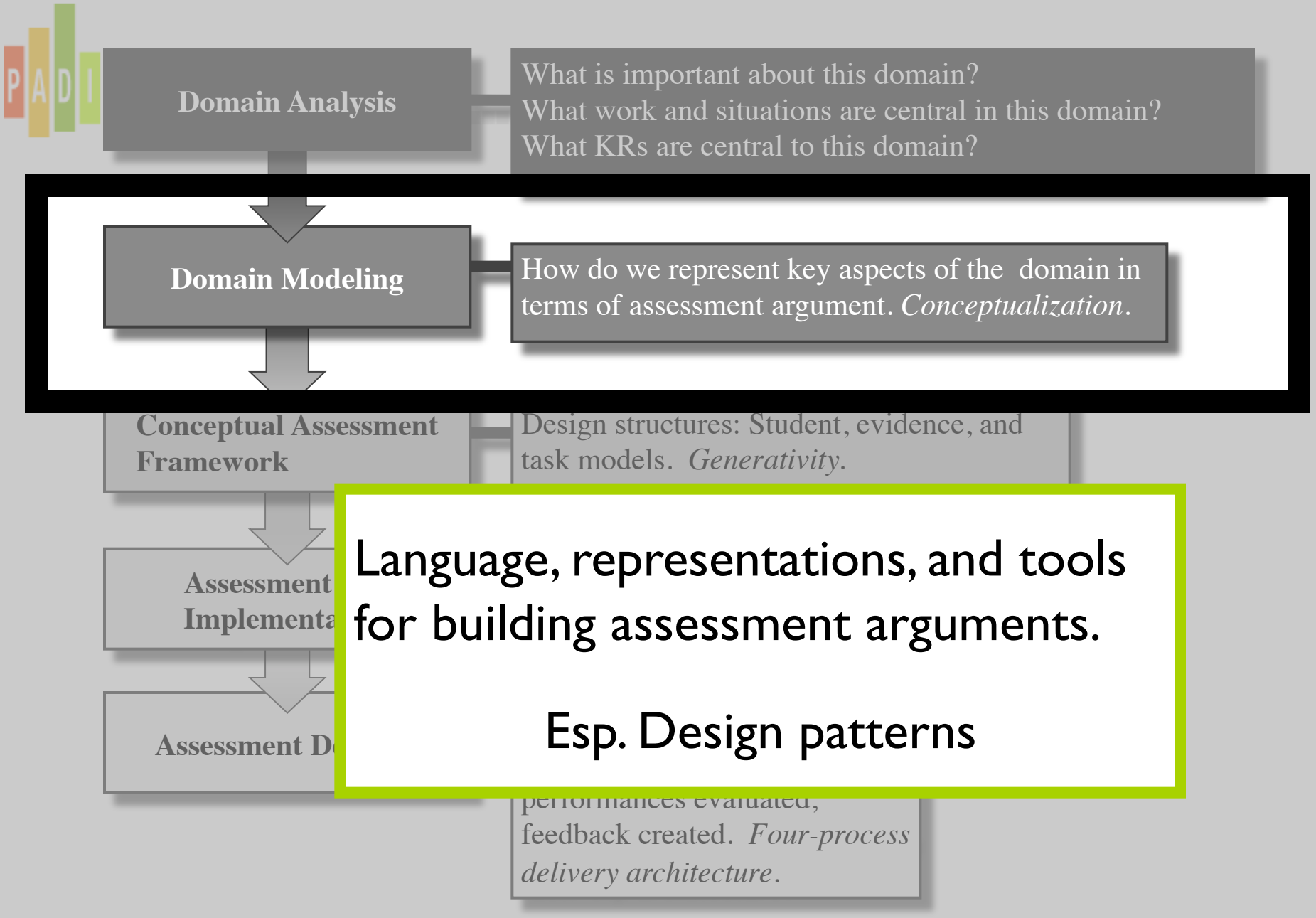
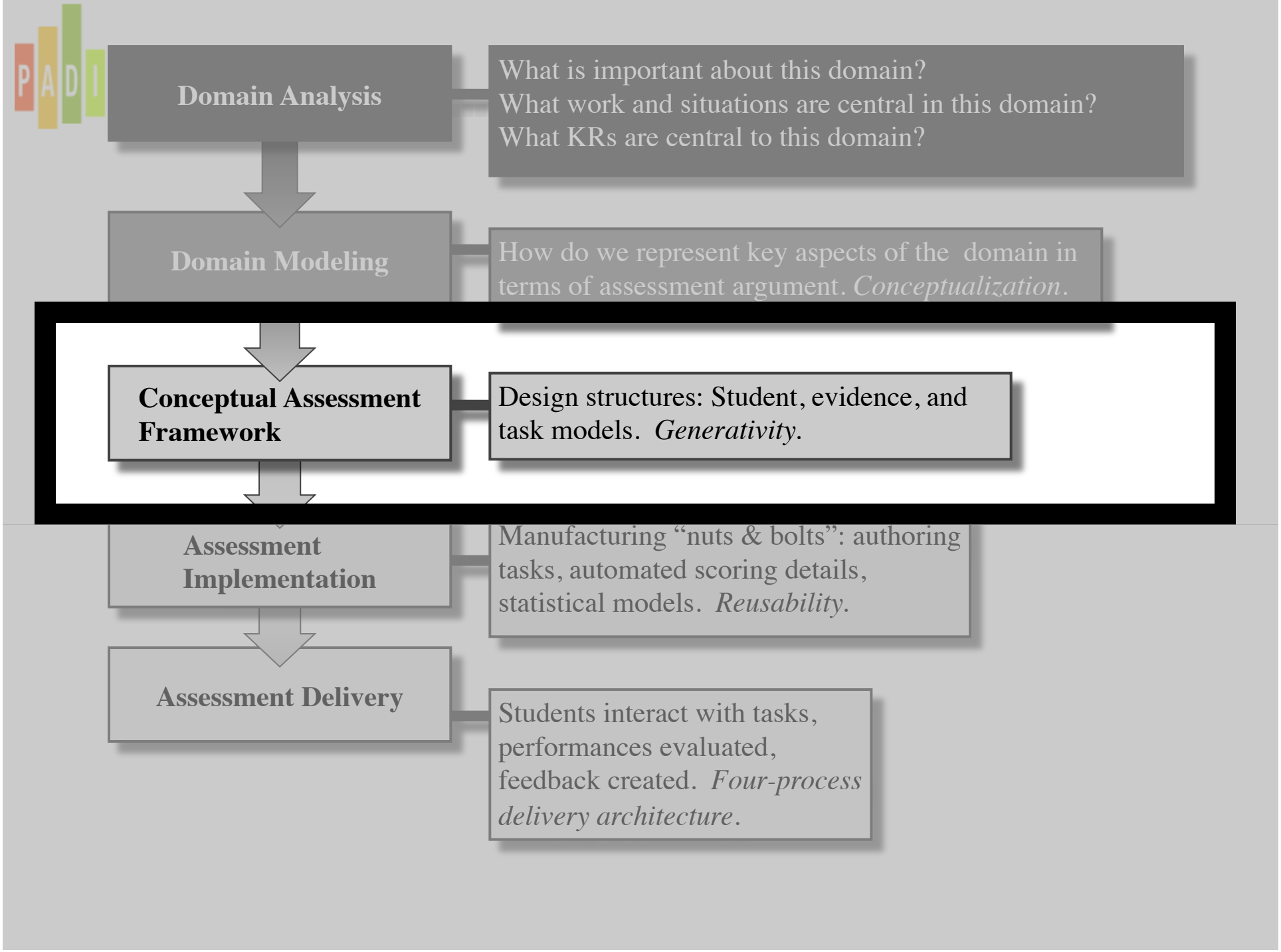


- From Mislevy& Riconscente, in press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Domain Analysis

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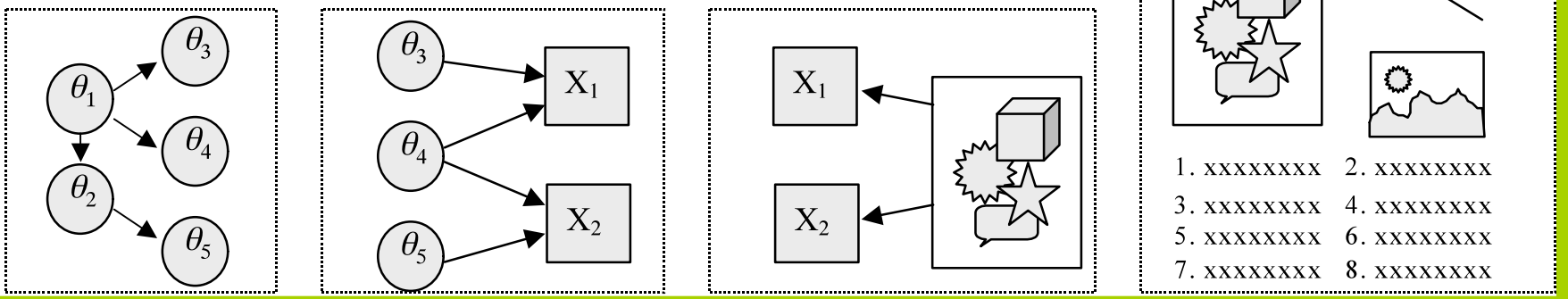
Student Model | Evidence Model(s) | Task Model(s)

Measurement Model

Scoring Model



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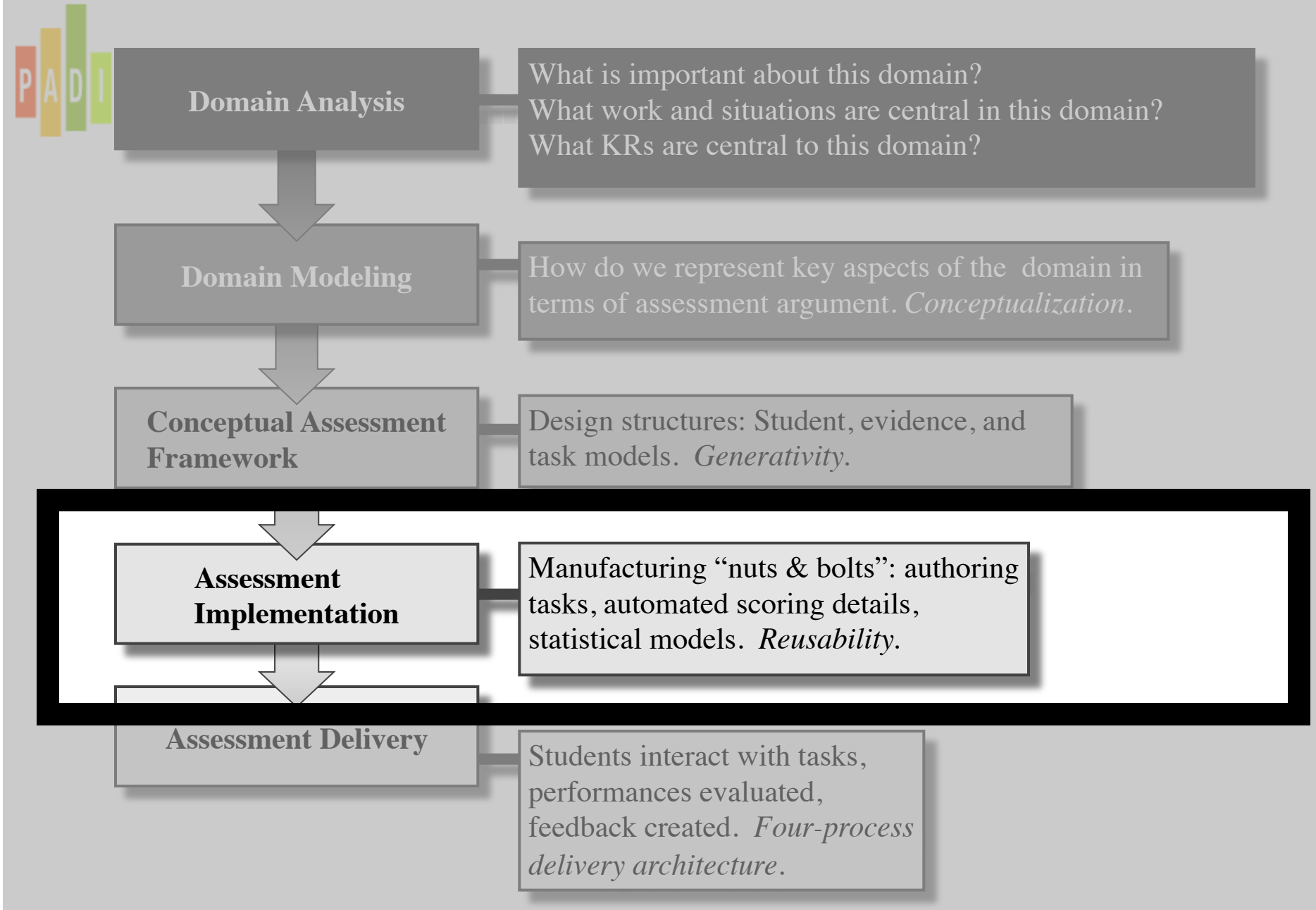
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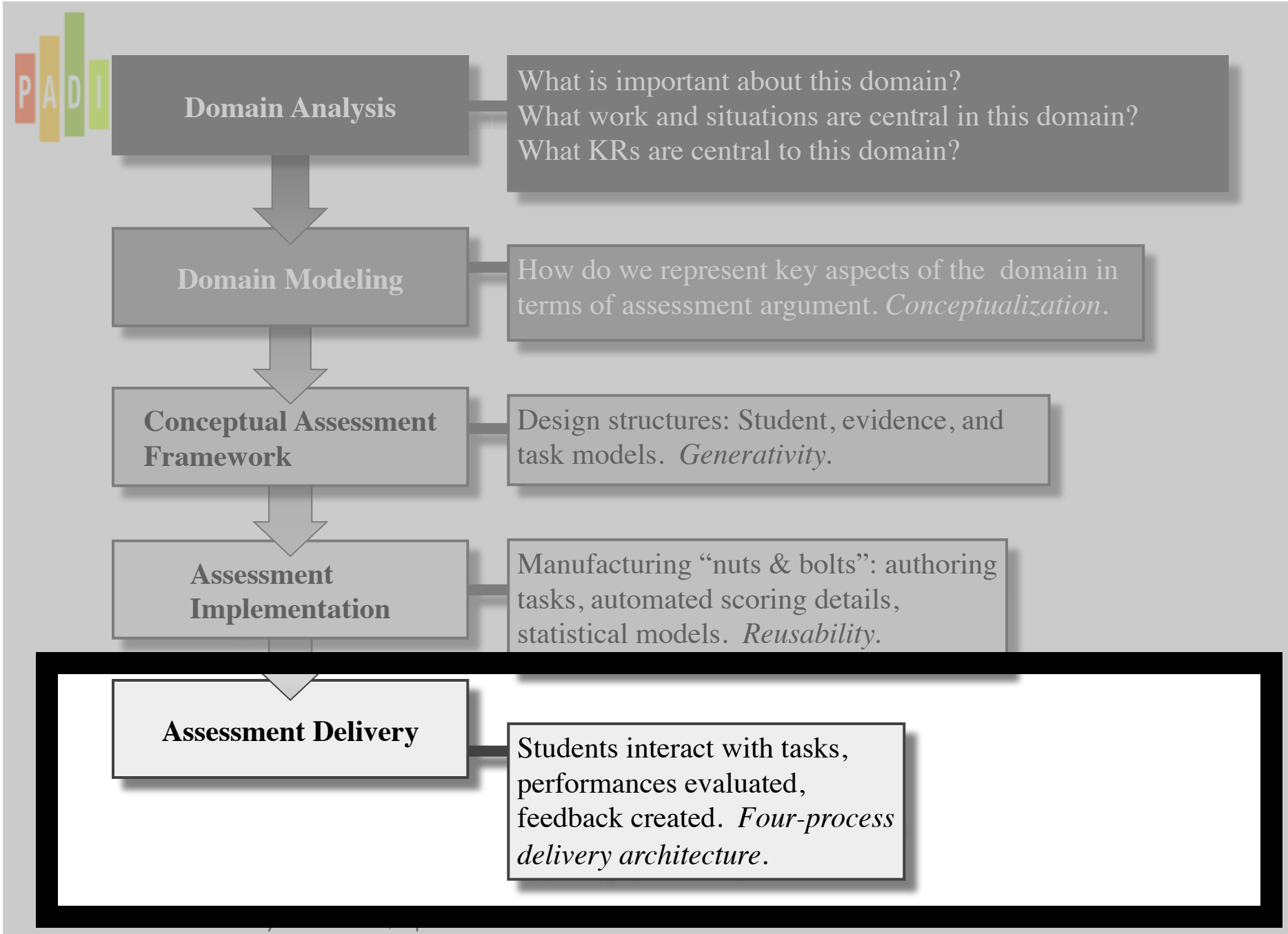
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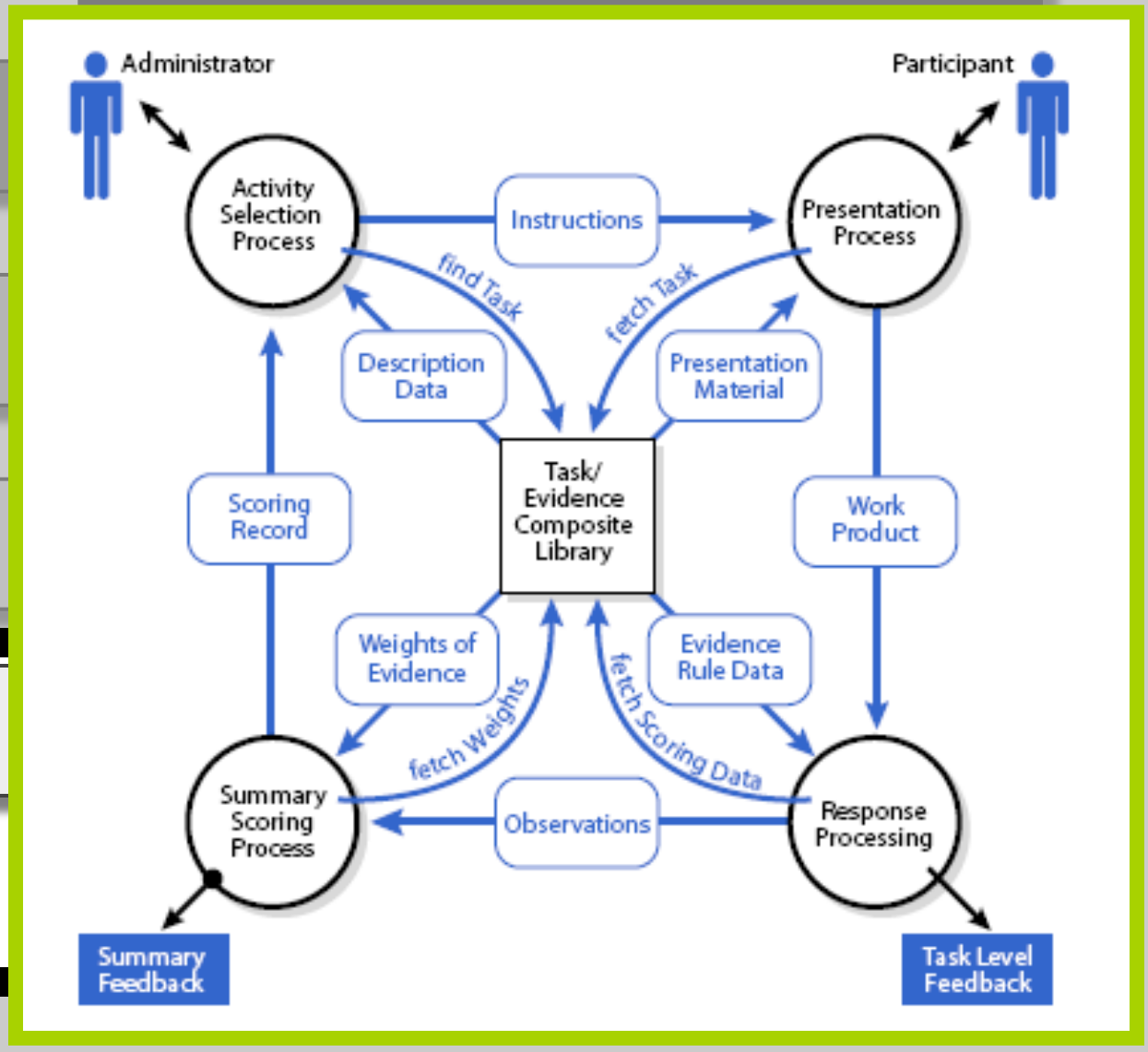

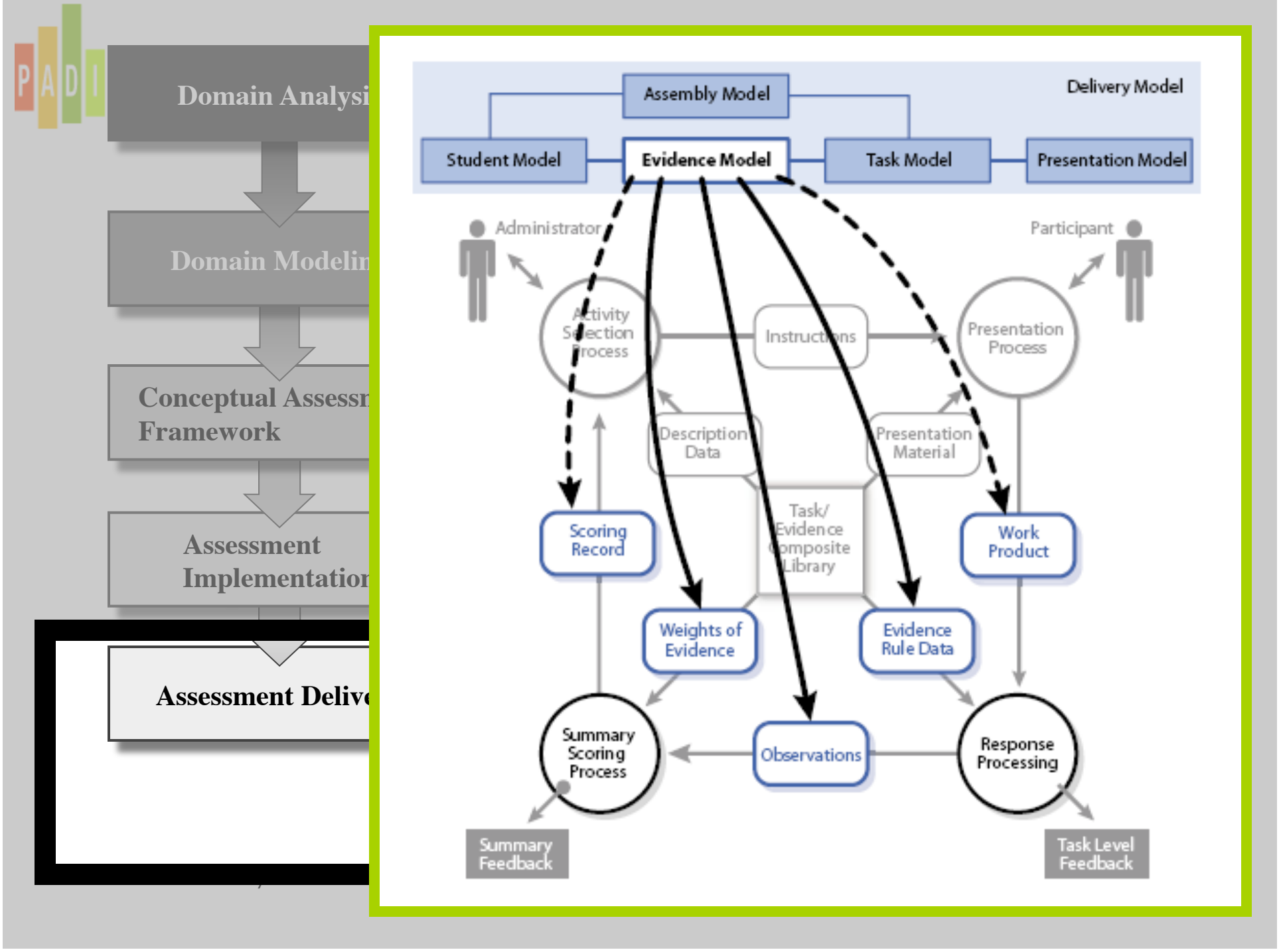
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Student Model
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Task Model
Presentation Model
Administrator
Participant
Activity
Selection
Process
Instructions
Presentation
Process
Description
Data
Presentation
Material
Task/
Evidence
Composite
Library
Scoring
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Product
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Task Level
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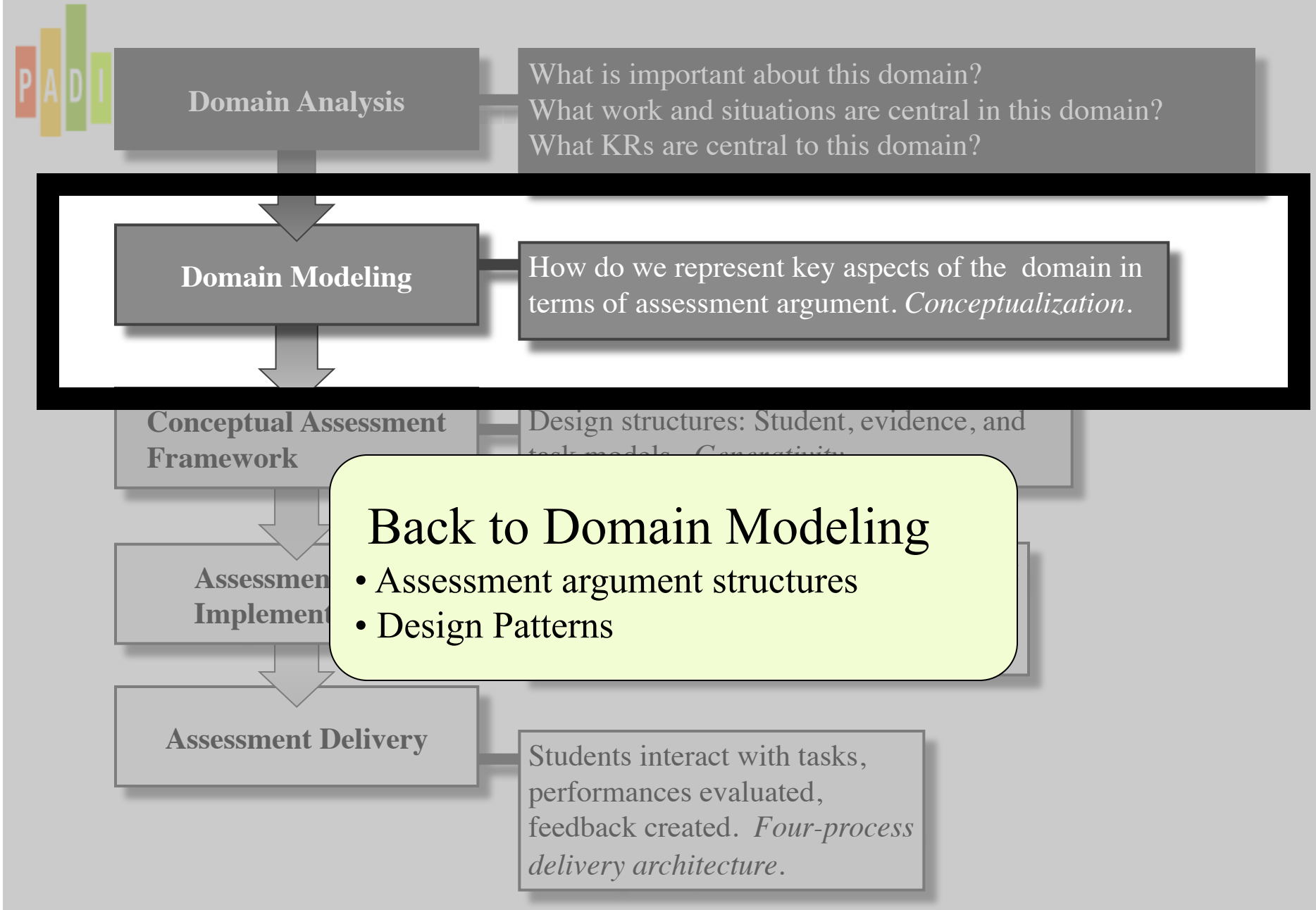


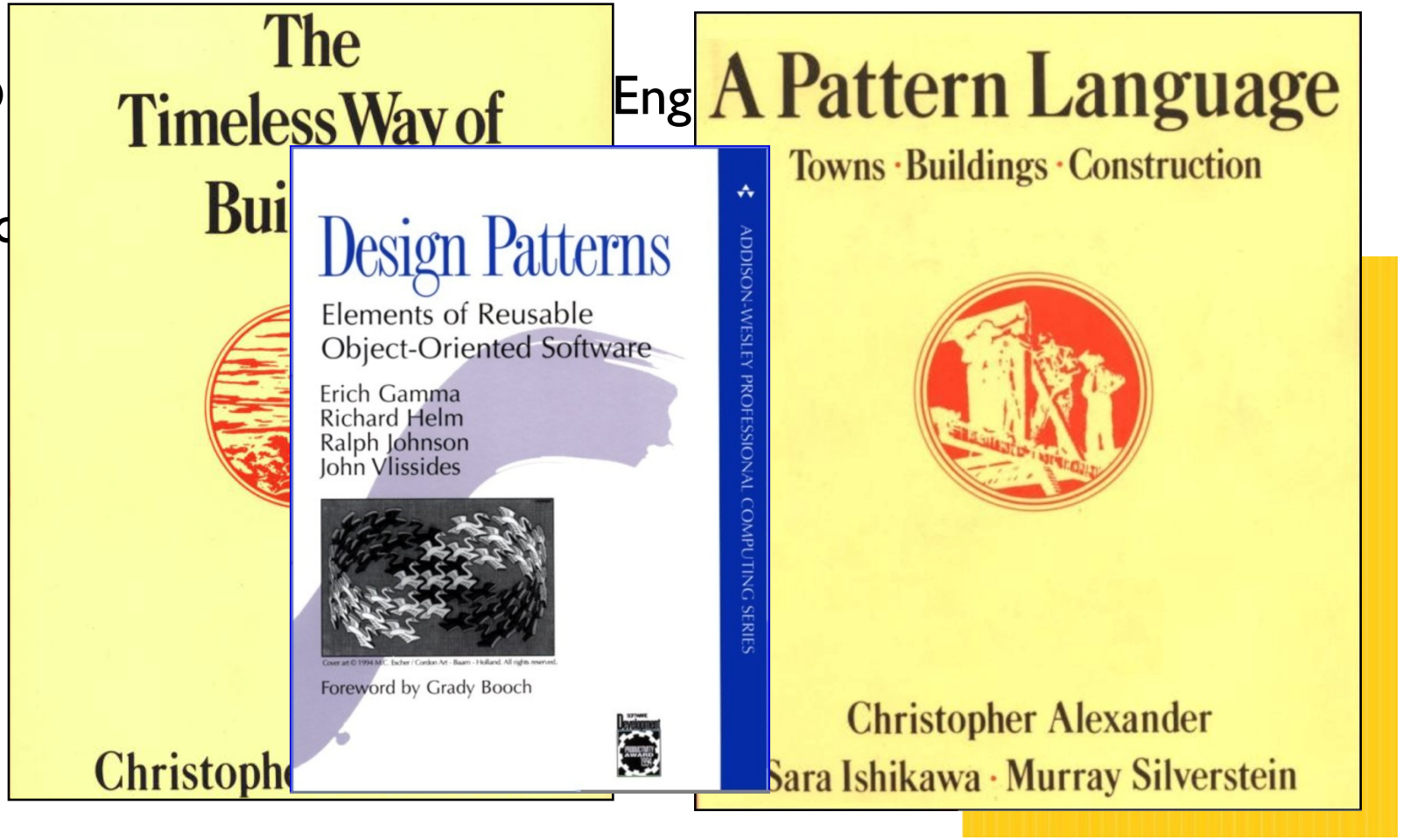
- From Mislevy & Riconscente, in press

What are Design Patterns?

- Solution to a problem that occurs repeatedly in our environment
- Specified at a level of generality that the underlying approach can be applied across many situations while adapting to the particulars of each case

What are Design Patterns?

- Design Patterns in Architecture
- D Eng
- Pc



Motivation for Assessment Design Patterns

- In-between structure, to connect...
  - Thinking about science learning & inquiry
  - Technical elements of measurement & delivery
- Narrative, not technical, contents
- Example Design Patterns from PADI
  - Model-Based Reasoning
    - Model Formation; Evaluation; Model Revision; Use
  - Observational & Experimental Investigations
  - Systems Thinking

Motivation for Assessment Design Patterns

- They lay out a design space for developers
  - Choices, connections, examples
  - Things to be aware of (e.g., research on Universal Design for Learning)
- Can improve both Efficiency + Validity
- Attributes reflect assessment argument structure

What are Assessment Design Patterns?

- Overview
- Focal Knowledge, Skills & Attributes (KSAs)
  - The primary KSAs targeted by the design pattern.
- Additional KSAs
  - Other KSAs that may be required for successful performance on the assessment tasks.
- Potential Work Products
  - Some possible things one could see students doing that would give evidence about the KSAs.

What are Assessment Design Patterns?

- Potential Observations
  - Features of the things students say, do, or make that constitute the evidence.
- Characteristic Features
  - Aspects of assessment situations that are likely to evoke the desired evidence.

What are Assessment Design Patterns?

- Variable Features
  - Aspects of assessment situations that can be varied in order to shift difficulty or emphasis.
- Narrative Structure
  - Type of storyline used as a framework for storyboard assessments (e.g., cause and effect).

Activity #1: Making Sense of Assessment Design Patterns

- Tasks
  - Match generic Design Pattern attributes with three components of Messick's assessment argument
  - Categorize example Design Pattern attributes within attribute categories
  - Report on group consensus
  - Discussion
- Resources
  - Components of Messick's assessment argument
  - Generic and Example Design Pattern attributes

Roadmap

- Where we have been:
  - Evidence-Centered Assessment Design
  - Assessment Design Patterns
    - Design space for helping task developers think about
      - Knowledge and skills to be measured
      - Behaviors that provide evidence of targeted knowledge and skills
      - Tasks that elicit the desired behaviors
- Where we are going:
  - How can I use a Design Pattern to select a storyboard topic for my scenario-based task?
  - Example based on MN state science standards and benchmarks, and PADI Design Pattern on Model Revision

High Level Summary of Assignment, MN State Standards and Benchmarks

Consider a storyboard assignment containing both content and Nature of Science* standards: 9.4.2.1, 9.1.1.1, 9.1.1.2

Interdependence Among Living Systems

Standard 9.4.2.1: The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.

Benchmarks:

9.4.2.1.1. Describe factors that affect the carrying capacity of an ecosystem and relate these to population growth.

9.4.2.1.2. Explain how ecosystems can change as a result of the introduction of one or more new species. For example: The effect of migration, localized evolution or disease organisms.

* *This is the name assigned to these standards in the state of MN; assessment developers are increasingly asked to write tasks that address both content and hard-to-assess inquiry- or practice-focused targets.*

High Level Summary of Assignment, Standards and Benchmarks

Nature of Science and Engineering

Standard 9.1.1.1: Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.

Benchmark:

9.1.1.1.7 Explain how scientific and technological innovations—as well as new evidence—can challenge portions of, or entire accepted theories and models including, but not limited to: cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease, and the big bang theory.

Standard 9.1.1.2: Scientific inquiry uses multiple interrelated processes to investigate and explain the natural world.

Benchmark:

9.1.1.2.2 Evaluate the explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the scientifically acceptable evidence, and suggesting alternative scientific explanations.

Selecting a Design Pattern

- Assigned MCA Science benchmarks
  - Describe factors impacting the carrying capacity of ecosystems
  - Explain how ecosystems can change as a result of the introduction of one or more new species
  - Explain how scientific and technological innovations, as well as new evidence, can be used to challenge portions of or entire accepted theories and models
- Potential Design Pattern
  - Model Revision

Selecting a Design Pattern

- Verify Choice of Design Pattern
  - review Overview and Characteristic Features
  - aligned w/ assigned inquiry-focused benchmarks?
    - models are used to represent scientific phenomena and can be revised to accommodate new evidence
  - inquiry process that can represented in storyboard for scenario-based task?

Selecting a Broad Storyboard Topic

- Potential Broad Topic
  - impact of invasive species on local ecology
- Verify Choice of Broad Topic
  - related to assigned content benchmarks on stable ecosystems / food webs?
  - related to assigned inquiry benchmarks on evidentiary reasoning?
  - aligned w/ Design Pattern attributes: food web is type of model and presence of invasive species represents a need for revision of the inadequate model?
  - rich topic that can exploited in a scenario-based task?

Specifying a Storyboard Topic

- Design Pattern & Broad Storyboard Topic
  - model revision
  - impact of invasive species on local ecology
- Potential Specific Storyboard Topic
  - introduction of the Burmese python into the Florida Everglades
- Verify Choice of Specific Topic
  - alignment w/ assignment, selected Design Pattern, broad topic?
  - cultural bias?
  - rich topic that has sufficient resources for populating a scenario-based task?

Activity #2: Brainstorm and Specify a Storyboard Topic

- Tasks
  - Review example assignment
  - Review Design Pattern Overview and Characteristic Feature
  - Review topic selections, and select and verify topic
  - Report on group consensus
  - Discussion
- Resources
  - Handout with example of assigned standards and benchmarks (content & nature of science)
  - Description of Observational Investigation Design Pattern attributes: Overview, Characteristic Features
  - List of potential topics

Roadmap

- Where we have been:
  - Assigned content and inquiry-focused standards and benchmarks (targets)
  - Multiple decision points:
    - Design Pattern(s) given assignment?
    - Broad task topic given assignment and design pattern(s)?
    - Specific task topic given assignment, design pattern(s) and broad topic?
  - To verify decisions about the storyboard topic, consider:
    - Alignment between assignment, design pattern(s), and broad and specific task topics
    - Extent to which inquiry process and topic can be represented in scenario-based task

Roadmap

- Where we are going:
  - How can I use a Design Pattern to write the storyboard scenes for my scenario-based task?

Select Focal KSAs to be Assessed in Storyboard

- Nature of Science standards and benchmarks are applicable across content areas and, as a result, can be more challenging to assess
- Design Patterns developed with the National Science Education Standards' unifying themes in mind
- Aligning Nature of Science standards and benchmarks with Focal KSAs in Design Patterns helps storyboard writers assess these challenging, but important areas

Select Focal KSAs to be Assessed in Storyboard

Nature of Science and Content Benchmarks	Model-Based Revision Focal KSAs
(Nature of Science) 9.1.1.2.2 Evaluate the explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the scientifically acceptable evidence, and suggesting alternative scientific explanations.	#2. Recognizing the need to revise a provisional model. #4. Justifying the revisions in terms of the inadequacies of the provisional model.
(Nature of Science) 9.1.1.2.2 See above (Content) 9.4.2.1.2 Explain how ecosystems can change as a result of the introduction of one or more new species	#3. Modifying the provisional model appropriately and efficiently.

Review Characteristic Feature(s)

- What are the characteristic features of tasks that need to be present in order to elicit evidence of the Focal KSAs?
- Characteristic Features of Model-Based Revision Tasks:
  - A situation to be modeled, a provisional model that is inadequate in some way, and the opportunity to revise the model in a way that improves the fit.

Review & Select Narrative Structure for Storyboard

All Narrative Structures	Plausible Narrative Structures	Selected Narrative Structure
Cause and effect - An event, phenomenon, or system is altered by internal or external factors.	✓	
General to specific - A general topic is initially presented followed by the presentation of specific aspects of the general topic.		
Investigation - A student or scientist completes an investigation in which one or more variables may be manipulated and data is collected.	✓	
Specific to general - Specific characteristics of a system or phenomenon are presented, culminating in a description of the system or phenomenon as a whole.	✓	
Topic with examples - A given topic is presented using various examples to highlight the topic.		
Change over time - A sequence of events is presented to highlight sequential or cyclical change in a system.		

- As the prevalence of the new invasive species increases, it results in sequential changes in the ecosystem over time

Review Design Pattern Attributes to Draw Implications for what will be Assessed

Characteristic Feature	Focal KSAs	Narrative Structure
A situation to be modeled, a provisional model that is inadequate in some way, and the opportunity to revise the model in a way that improves the fit	Recognizing the need to revise a provisional model.	Change over time
	Modifying the provisional model appropriately and efficiently.	
	Justifying the revisions in terms of the inadequacies of the provisional model.	

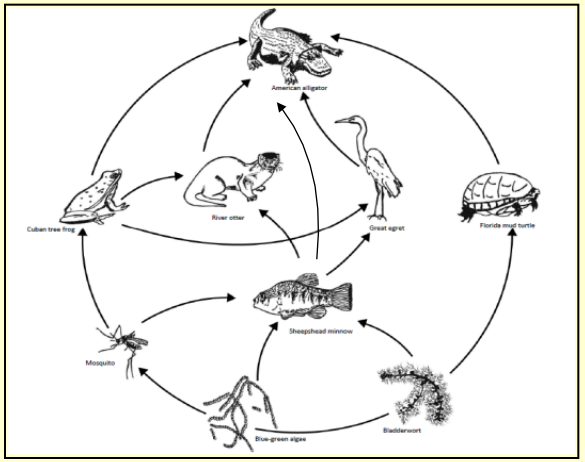
Implications For What Will Be Assessed

- Scenes in scenario-based task should give student an opportunity to:
  - recognize the original model is inadequate for the current ecosystem and needs to be revised to reflect change over time.
  - modify the original model to account for changes resulting from invasive species.
  - justify their model revisions.

Scene 1 – Recognize Original Model

Scenario Description (multimedia)

Everglades National Park is a large, warm, wetlands habitat in Florida. The food web for the Everglades includes many types of animals such as fish, birds, reptiles, insects, and mammals. Some Everglades animals are threatened species.



- What animals compete as consumers of the Sheephead minnow in this food web? (CR)
- What characteristic would help an animal thrive in the Everglades habitat? (MC)
  - Thick fur
  - Ability to store water
  - Ability to tolerate hot temperatures
  - Feet with long, separate toes

Scenario ID_scene	Storyboard Title	Subject	Grade	Art Type

Scene 2 – Recognize Original Model as Inadequate

Scenario Description (multimedia)

In the last decade a new snake, the Burmese python, has invaded the Everglades ecosystem. Starting in the 1990s, some pet owners released pythons into the Everglades. This large snake thrives in warm and wet habitats and is the top predator in its native southeast Asia habitat. Scientists in Florida have recorded the content of pythons' stomachs to include many types of mammals and birds.

Narration Control Panel

Stomach Content of Burmese Python in Florida

Mammals		Birds
• Rabbit • River Otter • Hispid Cotton Rat • Grey Squirrel • Fox Squirrel • Cotton Mouse • Old World Rats	• Virginia Opossum • Round-tailed Muskrat • Raccoon • Bobcat • Rice Rat • White-tailed Deer	• Pied-build Grebe • Limpkin • White Ibis • American Coot • House Wren

•If the small mammal population decreases due to disease, how will that affect the carrying capacity of the Everglades for the Burmese python? (CR)

• Based on the Burmese python's diet, how could a large number of Burmese pythons affect the Florida Everglades food web?

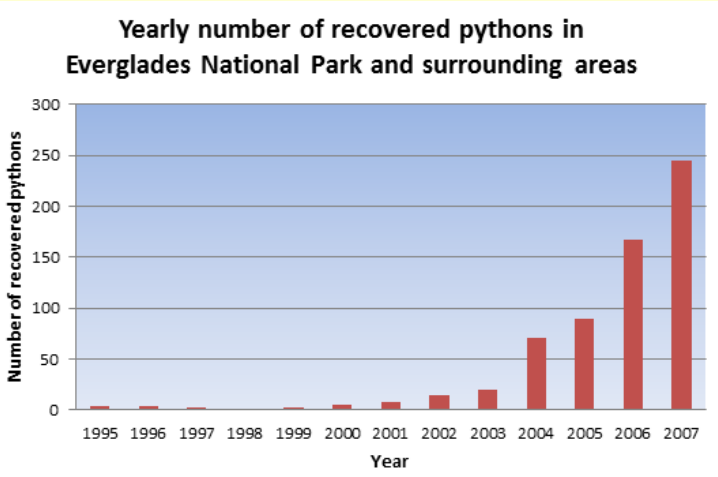
- •Because they eat birds, all of the water birds would disappear
- •Because they eat many types of mammals and birds, they compete at multiple levels of the food web
- •Because they don't eat fish, the fish population will stay the same
- •Because pythons compete with alligators, the population of turtles would increase

Scenario ID_scene	Storyboard Title	Subject	Grade	Art Type

Scene 3 – Recognize Original Model as Inadequate

Scenario Description (multimedia)

Everglades Park rangers estimate the size of the Burmese python population based on the number of pythons they find or capture. Over the past ten years, rangers have seen a change in the numbers of Burmese pythons that they count annually.

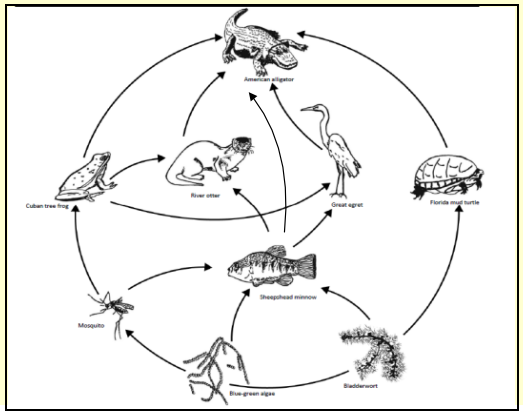


- What is the best conclusion about the data shown in the graph above? (MC)
  - The number of pythons was stable until 2001 and then increased through 2007
  - The number of pythons doubled every year
  - The python population reached its limit in 2007
  - Starting from 2004, the number of pythons began to level off
- What is the most likely reason for the growing population of Burmese pythons in the Everglades? (MC)
  - Presence of deep water
  - Availability of many types of grasses
  - A large mosquito population
  - Availability of many different types of prey
- If the population of Burmese pythons exceeded the carrying capacity of the Everglades habitat, what would happen?
  - The population of pythons would decrease
  - The population of pythons would increase
  - The population of alligators would decrease
  - There will be plenty of food left for other kinds of invasive species that have similar diet as the pythons

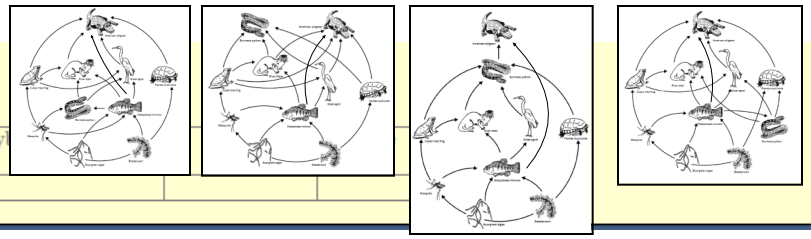
Scene 4 – Modify Original Model

Scenario Description (multimedia)

The Burmese python is now present in the Florida Everglades ecosystem. These pythons have a diet that is very similar to that of the American alligator.



1. Is the Everglades food web pictured above accurate? (MC)
   - No, because the food web doesn't contain any invasive species
   - Yes, because the food web shows animals that all live in the Everglades
   - No, because more types of tropical snakes should be added
   - No, because the American alligator should be removed
2. How should the original Everglades food web be updated? (MC)
   - Updating is not necessary
   - Add Burmese python as a secondary consumer
   - Add Burmese python as a primary consumer
   - Remove the alligator
3. Which food web best represents the current Everglades ecosystem? (MC)
   - Explain your choice (CR)



Scenario ID_scene	Story

Scene 5 – Justify Revised Model

Scenario Description (multimedia)

The Everglades is home to a number of threatened and endangered species. Without a successful program to capture and remove Burmese pythons, their population could increase dramatically and harm endangered species.

Narration Control Panel

- What are some potential impacts of an increased Burmese python population in the Everglades? (CR)
- When invasive species are introduced into an established ecosystem, what are scientists most likely to do to the original food web? (MC)
  - Keep the original food web because the invasive species will not survive
  - Revise the original food web by reversing all the arrows
  - Revise the original food web to include the new invasive species
  - Revise the original food web by moving decomposers and producers to the top

Scenario ID_scene	Storyboard Title	Subject	Grade	Art Type

Activity #3: Draft Storyboard Scenes

- Tasks
  - Review Assigned Standards and Benchmarks, Design Pattern Characteristic Feature, Focal KSAs and Narrative Structures
  - Select Focal KSAs
  - Select Narrative Structure
  - Brainstorm implications for what needs to be assessed given Characteristic Feature, Focal KSAs, Narrative Structure
  - Brainstorm ideas for storyboard scenes given implications for what needs to be assessed – you can describe the overall storyline, or a couple of specific scenes.
  - Report on group consensus
  - Discussion

Activity #3: Draft Storyboard Scenes

- Resources
  - Handout with example assigned standards and benchmarks
  - Copy of Observational Investigation Design Pattern
  - Table relating Characteristic Feature, Focal KSAs, Narrative Structure
  - Definitions of Narrative Structures
  - Assigned topic

Roadmap

- Where we have been:
  - using a Design Pattern to brainstorm and specify a storyboard topic for a scenario-based task
  - using a Design Pattern to write the storyboard scenes for a scenario-based task
    - Multiple decision points:
      - Focal KSAs given assigned standards and benchmarks?
      - Narrative Structure given Characteristic Feature(s), Focal KSAs and assignment?
      - Implications for what will be assessed given Narrative Structure, Focal KSAs and assignment?
      - Scenes given implications for what will be assessed?

Roadmap

- Where we have been:
  - To verify decisions about scenes, consider:
    - Alignment between assignment, Focal KSAs, Narrative Structure
    - Extent to which scenes encompass implications for what will be assessed
- Where we are going:
  - How can I use a Design Pattern to sketch and fine-tune item ideas?

Sketch Item Ideas

What counts as evidence of the Focal KSAs that I am measuring and how will I elicit that evidence in my task scenes?

Focal KSAs	**Potential Observations (evidence)**	**Potential Work Products (instantiation of evidence)**	**Item Ideas (how to elicit evidence)**
Modifying the provisional model appropriately and efficiently	Quality or appropriateness of model revisions in order to address inadequacies of provisional model	Choice or production of revised model	How should the food web be updated?
Justifying the revisions in terms of the inadequacies of the provisional model	Quality of the basis on which students decide that a revised model is adequate	Explanation of reasoning for revised model	Please justify your updates to the food web.

Fine-tune Item Ideas

- Additional KSAs
  - *Ask*: Are the item ideas focused too heavily on eliciting performances and behaviors consistent with the Additional KSAs (*not* the Focal KSAs)?
  - *Example*: embedded items focus on real-world situation unfamiliar to most students completing assessment
- Variable Features
  - *Ask*: Are there ways to vary features of the item ideas to, for example, make them more or less difficult?
  - *Example*: make embedded items more difficult by asking students to develop model during an investigation, rather than asking them to revise a given model

Activity #4: Sketch & Fine-Tune Item Ideas

- Tasks
  - Review Focal KSAs, Potential Work Products and Observations
  - Review and select Potential Work Products & Observations
  - Draft one or two item ideas
  - Review Additional KSAs and Variable Features
  - Discuss how Additional KSAs could be used to identify sources of measurement error in your item ideas
  - Discuss how Variables Features could be used to shift the difficulty or emphasis or your item ideas
  - Report on group consensus
  - Discussion

Activity #4: Sketch & Fine-Tune Item Ideas

- Resources
  - Example assigned standards and benchmarks (content & nature of science)
  - Copy of Observational Investigation Design Pattern
  - Table relating Characteristic Feature, Focal KSAs, Potential Work Products and Observations

Roadmap

- Where we have been – using an Assessment Design Pattern to:
  - brainstorm and specify a storyboard topic for a scenario-based task
  - write storyboard scenes for a scenario-based task
  - sketch and fine-tune item ideas

Roadmap

- Multiple decision points:
  - Focal KSAs given assigned standards and benchmarks?
  - Narrative Structure given Focal KSAs and assignment?
  - Implications for what will be assessed given Characteristic Features, Narrative Structure, Focal KSAs and assignment?
  - Scenes given implications for what will be assessed?
  - Item ideas given scenes, Focal KSAs, Potential Work Products and Observations

Roadmap

- To verify decisions about item ideas, consider:
  - extent to which items ideas will elicit the types of behaviors that will count as valid evidence of the Focal KSA
  - how Additional KSAs could be elicited by the items ideas and the extent to which this will lead to measurement error
  - how Variable Features could be used to change the difficulty or emphasis of the item ideas to improve alignment with the Focal KSAs

Roadmap

- Where we are going:
  - Summary - How can I use Assessment Design Patterns to Write Storyboards for Scenario-Based Tasks?

How Can Design Patterns Help Me Write Stronger Storyboards?

Design Pattern Attribute(s)	Helps with…
Overview & Characteristic Feature(s)	Identifying key features of the storyboards, particularly the topic, that must be included so that they are aligned with standards, benchmarks and Focal KSAs
Focal KSAs	Supporting development of scenes and storyboards that are aligned with hard-to-assess topics that are applicable across content areas (e.g., observational investigation)
Potential Work Products & Observations	Indicating scene contexts that are appropriate for eliciting desired evidence; sketching item ideas for storyboard scenes that will elicit the desired evidence

How Can Design Patterns Help Me Write Stronger Storyboards?

Design Pattern Attribute(s)	Helps with…
Additional KSAs	Ensuring that items ideas, scenes and the overall storyboard do not stress content or behaviors that are not relevant to target of the assessment
Variable Features	Identifying features (e.g., narratives, knowledge representations) of storyboards, scenes and item ideas that can be varied to adjust task difficulty or emphasis

Thank You!

- Questions / Feedback?
  - Eric Snow – eric.snow@sri.com
- Interested in finding out more about Assessment Design Patterns?
  - http://ecd.sri.com
  - Project information
  - Design patterns
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