Thinking about Learning Objectives

Krishna Madhavan

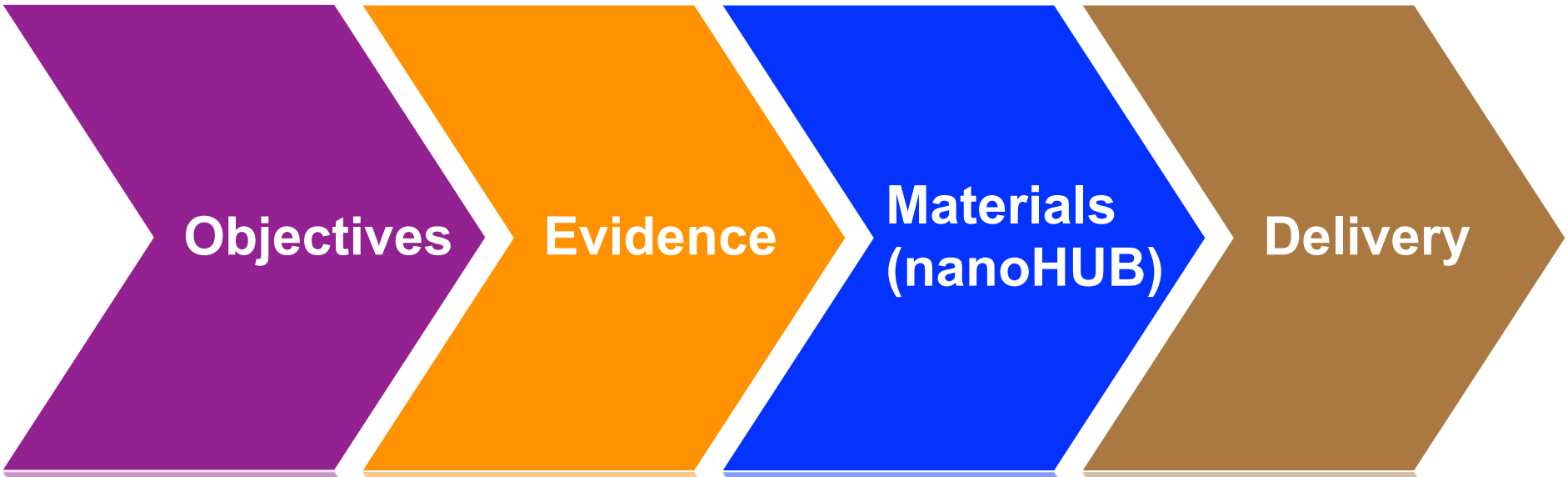
Network for Computational Nanotechnology (NCN)

School of Engineering Education

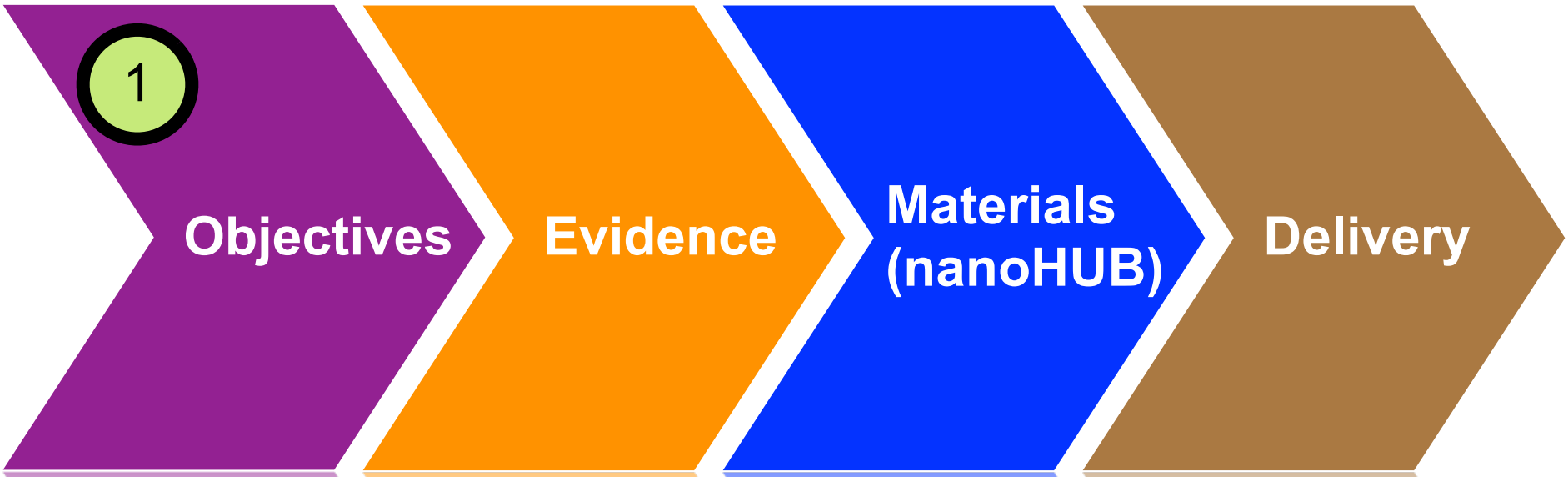
cm@purdue.edu

Chicago, IL

Design Process: Reverse Engineering

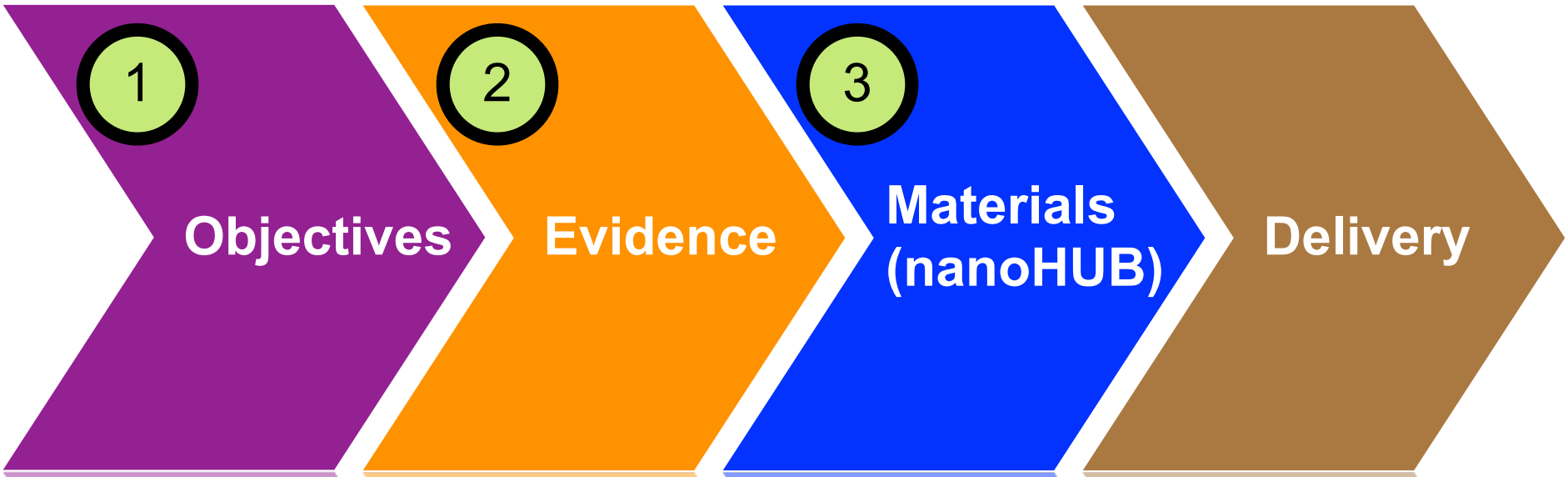


Design Process: Reverse Engineering

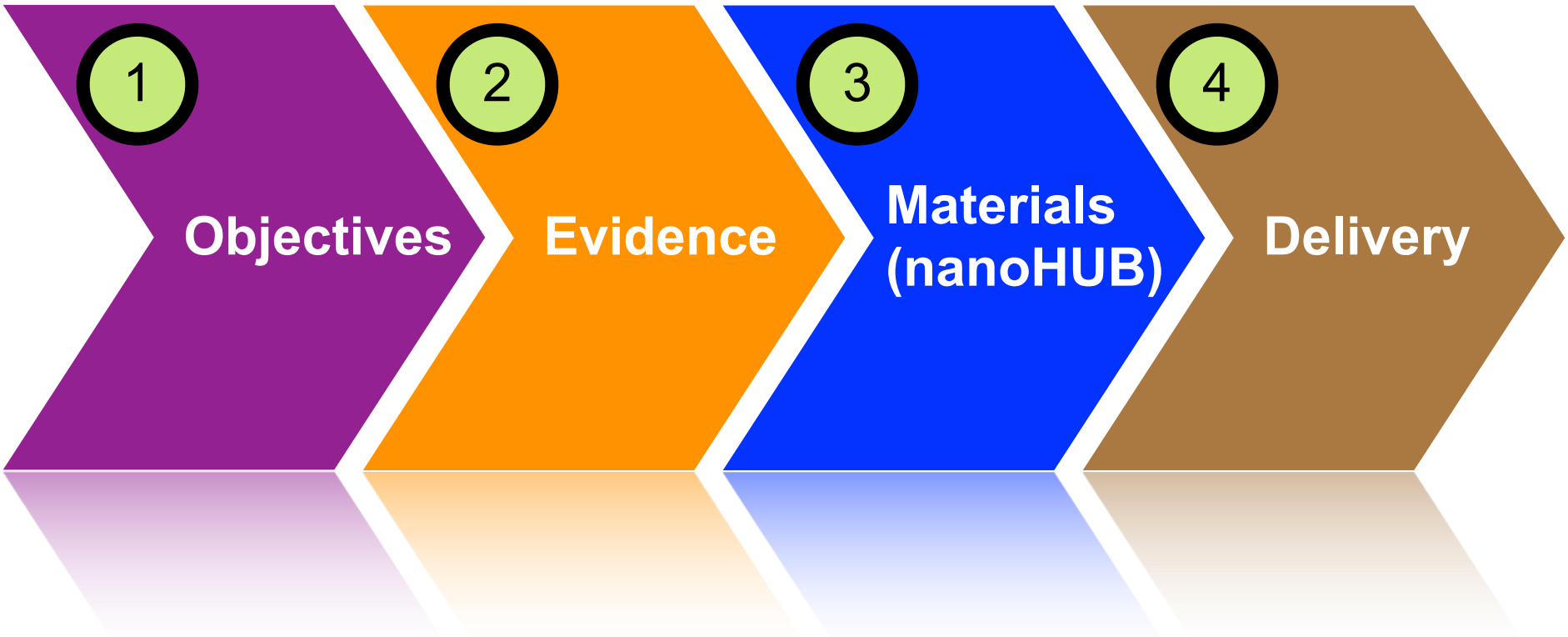


Design Process: Reverse Engineering

Design Process: Reverse Engineering



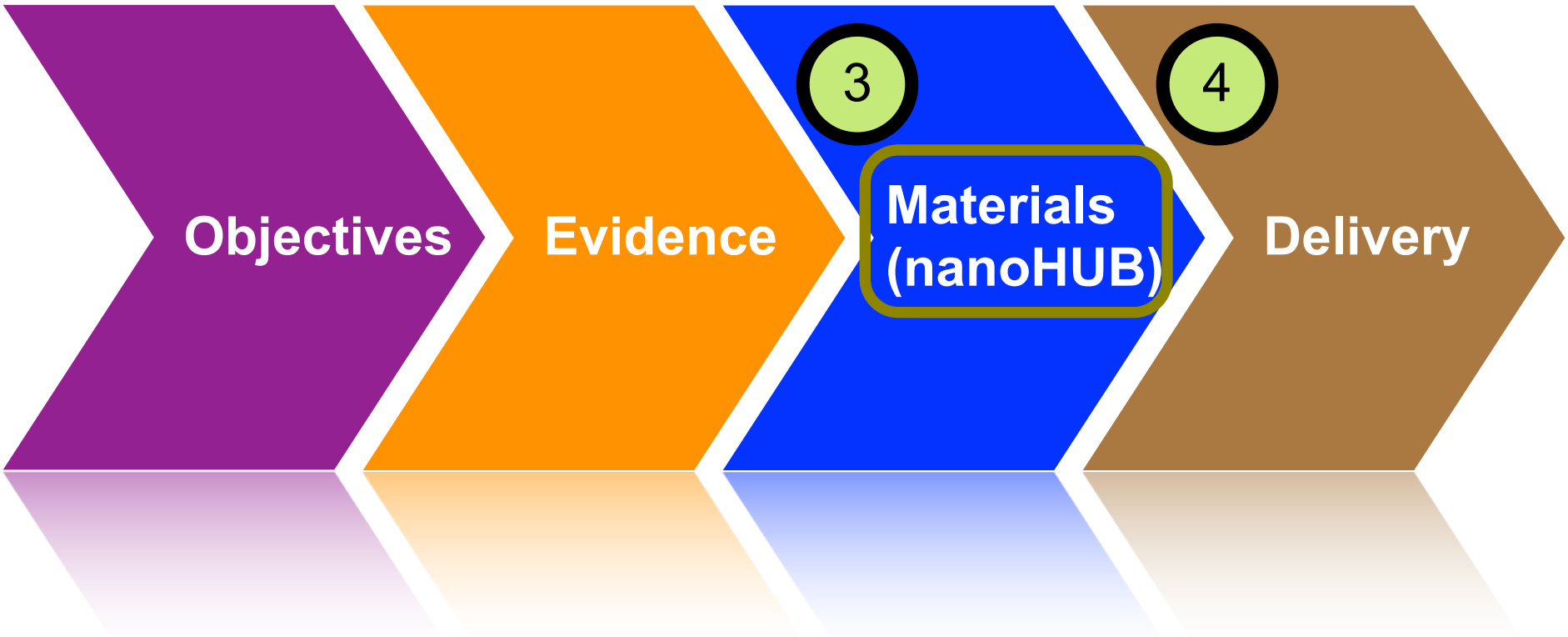
Design Process: Reverse Engineering



Design Process: Reverse Engineering

Design Process: Reverse Engineering

Design Process: Reverse Engineering



Design Process: Reverse Engineering

Design Process: Reverse Engineering

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	ranslate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	**Identify**	emonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discrimin	**Propose**

Imbrie and Brophy, 2007

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Employ	Distinguish	Select	Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translat			
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Demonstrate	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Propose

Increasing complexity

Imbrie and Brophy, 2007

Learning Objectives – Example from ENGR 195 (at Purdue)

- Most engineering students need to understand how to use computational tools
- To this end, they need to know some programming
- Flowcharts allow students to understand programming flow/logic
- Also helps them understand the role of standard representations

Learning Objectives – Example from ENGR 195 (at Purdue)

- At the end of this class/session, you will be able to….

  - »**Use** Flowcharting as a tool to support your design process
    - ✓**Identify** specific shapes used in flowcharts
    - ✓**Distinguish** between the function of the various shapes

  - »**Apply** conditional statements and loops/iterations as part of your flowchart generation process

Learning Objectives – Example from ENGR 195 (at Purdue)

- At the end of this class/session, you will be able to….

»**Use** Flowcharting as a tool to support your design process

✓**Identify** specific shapes used in flowcharts

✓**Distinguish** between the function of the various shapes

»**Apply** conditional statements and loops/iterations as part of your flowchart generation process

Use **Identify** **Distinguish** **Apply**

The Cognitive Process Dimension

The Knowledge Dimension

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge – The basic elements that students must know to be acquainted with a discipline or solve problems in it. a. Knowledge of terminology b. Knowledge of specific details and elements	Recall	Restate	Emplo			Arrange
Conceptual Knowledge – The interrelationships among the basic elements within a larger structure that enable them to function together. a. Knowledge of classifications and categories b. Knowledge of principles and generalizations c. Knowledge of theories, models, and structures	Define	Describe	Translate	Compare	Defend	Combine
Procedural Knowledge – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. a. Knowledge of subject-specific skills and algorithms b. Knowledge of subject-specific techniques and methods c. Knowledge of criteria for determining when to use appropriate procedures	Relate	Identify	Apply	Contrast	Interpret	Construct
Metacognitive Knowledge – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition. a. Strategic knowledge b. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge c. Self-knowledge	Review	Express	Examine	Deduce	Discriminate	Use

Distinguish

Imbrie and Brophy, 2007

Writing Learning Objectives

- Begin with the **big concepts** that you want students to know
- Identify the **sub-concepts/pre-requisites** that are needed
- Use **specific action words** from Revised Bloom's Model
- Think about how you would **measure** these objectives

Examples from the use of nanoHUB

- Some examples from the use of nanoHUB:
  - » ***Identify*** the cause-effect relationship of the underlying model
  - » ***Validate*** the results or performance of an experiment
  - » ***Predict*** the results and/or performance of an experiment or design task

» **Source:** Alejandra J. Magana (2010), "How engineering instructors use nanoHUB simulations as learning tools?," http://nanohub.org/resources/8742.