

# Using Construct-Centered Design to Align Curriculum, Instruction, and Assessment Development in Emerging Science



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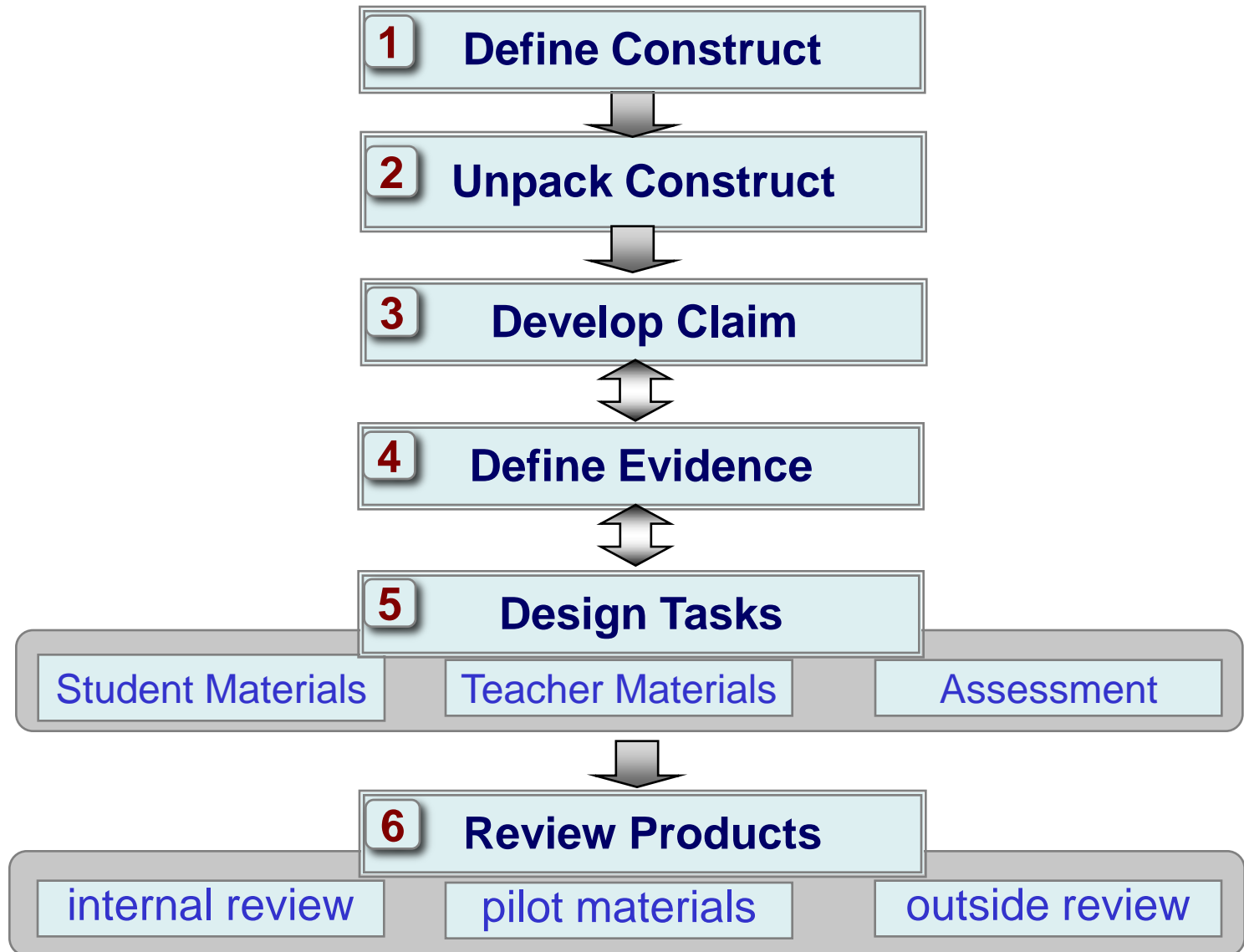
# Overview

- Introduction to Construct-Centered Design
- Areas of application within NCLT
- Benefits & Limitations

# Construct-Centered Design (CCD)

- What is CCD?
  - Adaptation of aspects of learning-goals-driven design (Krajcik, McNeill, & Reiser, 2007) and evidence-centered design (Mislevy, et al., 2003; Pellegrino, et al., 2001)
    - Define knowledge domains (construct)
    - Use construct to align development of curriculum, instruction, and assessment
- Why use CCD?
  - Provides a systematic approach to developing instructional materials (for students and teachers), and assessment (formative & summative)
  - Facilitates the development of principled, coordinated research on teaching and learning

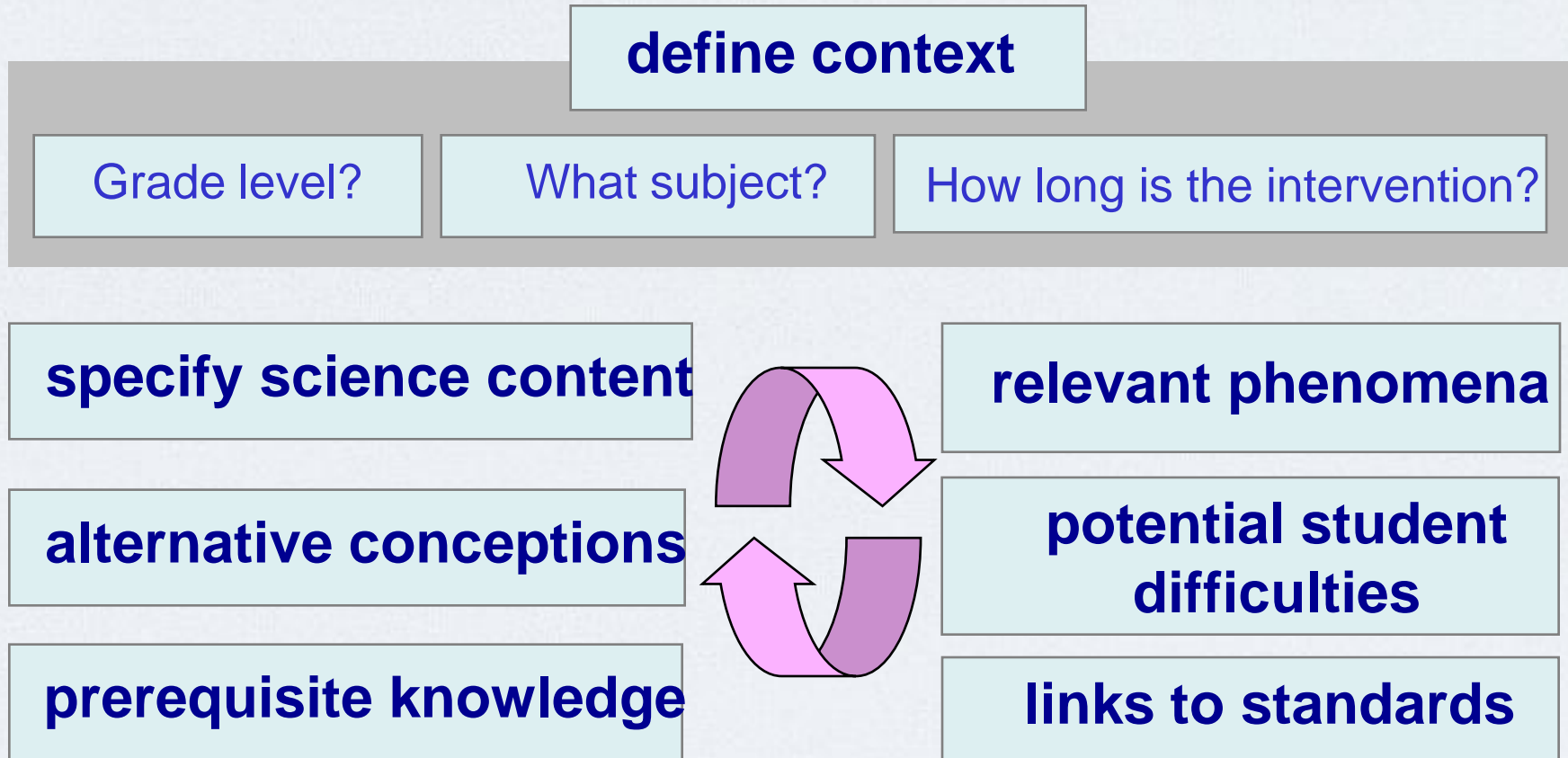
# Stages of CCD Process



# 1. Define the Construct

- These might be derived from a set of “big ideas” in science or from standards or benchmarks
- Includes concepts that are not just related somehow to a big idea, but *necessary for building understanding* of the big idea
- Approach and “grain size” depend on the desired final product and intended use

## 2. Unpack Construct



# 3. Develop Claims

- A claim is about what the student “knows” and “understands” and how they do so
- Incorporates both content and cognitive skills
- Uses descriptive and specific verbs to clarify learning performances. For example:
  - describe, analyze, compare and contrast, design
  - explain content using evidence and reasoning
  - build and describe models

## 4. Define Evidence

- What will you accept as **evidence** in support of a **claim** that a learner has the desired knowledge?
- Specific learner performances and/or work products that you would accept as indicative that a **claim** has been satisfied.
- The **features** of the work products and performances that you expect to see and their value and importance in supporting a **claim**

# An Example from NCLT Research

## Content Domain

Kinetic theory: Particles/atoms are always in motion (except at 0° K)

Claim	Evidence
<p><i>The student is able to:</i></p> <p>incorporate particle motion into their descriptions of the structure of matter</p>	<p><i>The student work should include:</i></p> <ol style="list-style-type: none"><li>1. a description of the behavior of the particles that make up matter</li><li>2. a model of matter that includes:<ul style="list-style-type: none"><li>- all matter is made up of particles/(atoms)</li><li>- the particles are too small to see with the naked eye.</li><li>- the particles that make up matter are in constant motion</li><li>- the inherent motion is often called thermal energy</li></ul></li></ol>

# 5. Design Situations or Tasks

- What particular tasks, questions or situations will
  - help students develop knowledge
  - bring about a response

that will provide sufficient evidence to support the student learning claim

- A single task or situation may provide evidence for more than one claim.
- Multiple tasks and performances may be necessary to provide evidence in support of a single claim.

# Example from NCLT Research: Developing an Instrument

## Content Domain

Kinetic theory: Particles/atoms are always in motion (except at 0° K)

### Task

#### *Probe from an Interview Protocol*

If we have a special instrument that allows us to zoom in and see what this piece of metal is made of, what would we see? Draw what you think it will look like and explain your model.

# 6. Review Products

- Based on the internal and external reviews and pilot studies, iterate through relevant portions of the design process.
- Confirm that the products meet all CCD criteria
  - who they are intended for
  - how they are intended to be used

# Some CCD Examples within NCLT

- Research on Student Understanding
  - Learning Progressions (UM)
- Development of Student Materials
  - Summer Science Camp (UM & UIUC)
    - Curriculum with learning technology
  - Learning assisted by Technology (UIC)
- Teacher Materials
  - Professional Development (Purdue & UIC)

*These applications encompass development of curriculum materials, learning technology, teacher education, and assessment, in addition to research efforts.*

# Example Development of Student Materials

- Learning of critical content assisted by technology
- Purpose
  - To develop curriculum materials and instruction strategies for middle school students to teach about interactions of energy with matter
- Big ideas
  - Forces & Interactions, and Self-Assembly

# Focus of Student Materials

Big idea: Forces & Interactions, and Self-Assembly

Claim	Evidence
<i>The student is able to:</i>	<i>The student work should include:</i>
predict how changes of energy affect the movement of atoms as materials change structure.	<i>(Shown a comparison of the same material at different temperatures), a written description of</i> <ul style="list-style-type: none"><li>- every substance has heat, regardless of its temperature.</li><li>- that the system has less heat/energy at lower temperatures, while at higher temperatures it has more</li></ul>

# Focus of Student Materials

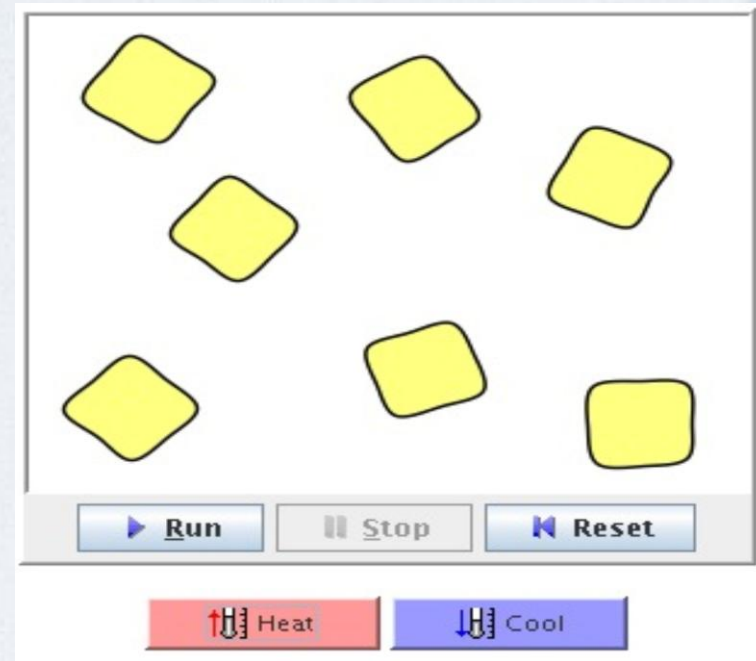
Big idea: Forces & Interactions, and Self-Assembly

## Task (Learning)

*Computer simulation*

*[Given a simulation of four atoms exhibiting random motion in a system whose energy can be manipulated by a heat gauge]*

Describe the movement of these atoms and what happens when the temperature of the system is increased or decreased. Why does this occur when the temperature is changed?



Molecular Workbench simulation.

# Uses & Benefits of CCD

- Helps to organize the content within the big idea
- Helps ascertain how well an activity or performance characterizes student understanding of *all* of the content within the big idea
- Provides a clear chain of reasoning from big idea to curriculum, instruction & assessment to help ensure coherence and construct validity, as well as alignment.

# Limitations

- The initial part of the process (define and unpack a construct) can be very specific and overly narrow -- need to consider a “useful grain size” and avoid and infinite regress
- It’s a process, not a cookbook recipe, so it is still challenging to create assessment and curricular materials.
- There are challenges in identifying and clarifying the differences and relationships among claims, evidence, and tasks

# A Possible Metaphor for What the NCLT is Trying to Do Using Construct-Centered Design

# Self-Assembly

Is it a “big idea”?

What concepts are affecting it?

What claims can be formulated using this approach?

Which concepts to unpack?

At what level should they be unpacked?

What evidence can support the claims?

Can self-assembly be used as a vehicle for learning about these concepts?

What tasks can demonstrate the evidence?

What prior knowledge to consider?

How to develop instruction that aligns with the claim-evidence-task?

Where and how should design activities be incorporated?

Can one instruction respond to more than one claim?

What instructional method/sequence is optimal?