

Developing Standards that Lead to Better Instruction and Learning

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**Best Practices in State
Assessment Workshop**

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Standards and the education system

As the foundation of education system, standards should:

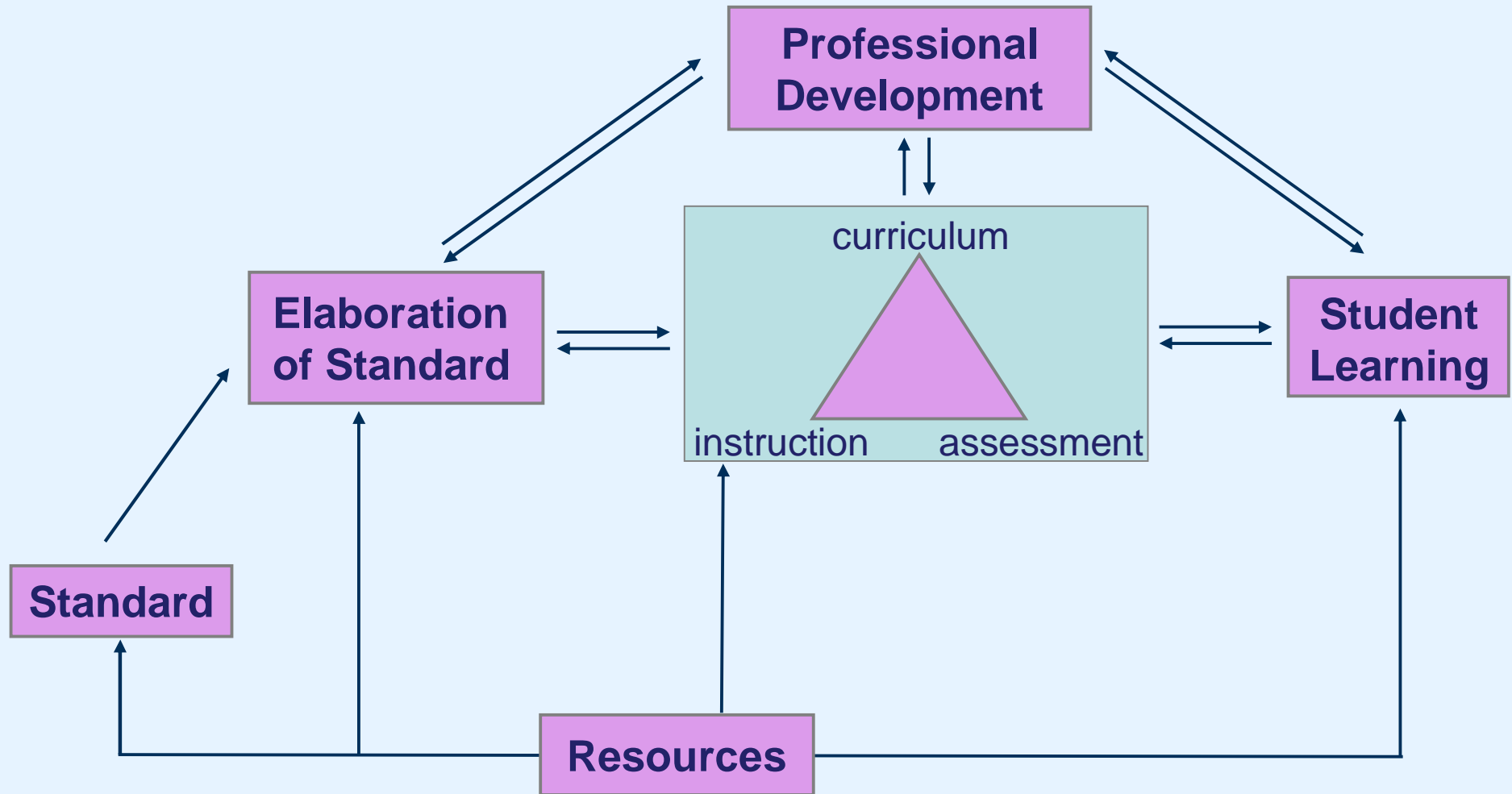
- Provide clear and measurable expectations for students
- Make educational goals explicit

However, current national, state and local standards:

- contain too many standards
- give equal priority to all the standards
- stated in declarative form which are subject to interpretation

Thus, standards are not providing a guide for development of coherent curricula—a key factor in predicting student achievement (Schmidt, et al., 2005)

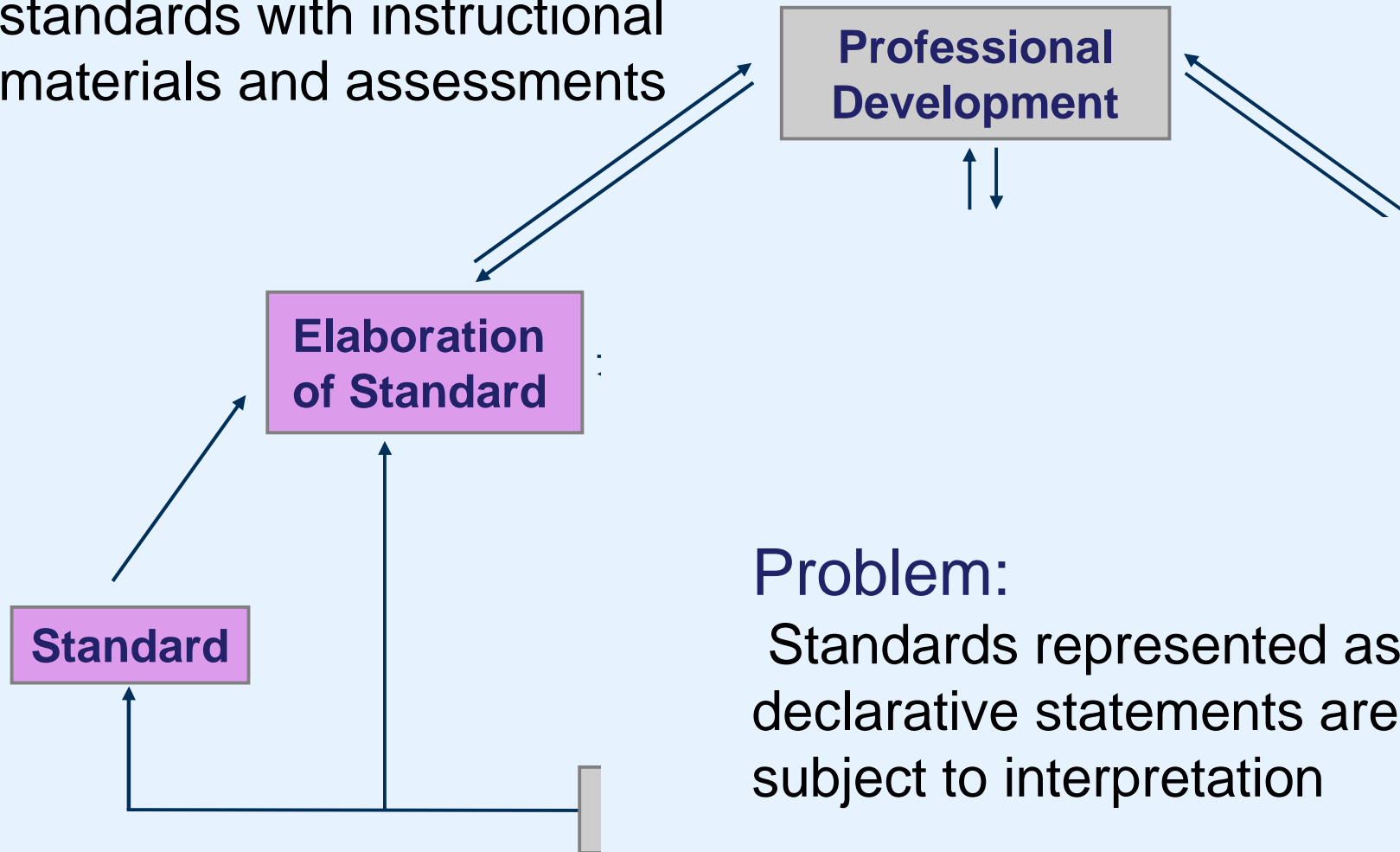
Standards in the science education system



(Adapted from *Systems for State Science Assessment*, NRC, 2006)

Elaboration of standards

An important step in connecting standards with instructional materials and assessments



Problem:

Standards represented as declarative statements are subject to interpretation

(Adapted from *Systems for State Science Assessment*, NRC, 2006)

Theoretical Foundations

1. An individual makes sense out of various ideas and experiences by connecting related concepts, principles and factual knowledge to each other that create conceptual frameworks
2. Because integrated understanding is built upon conceptual frameworks we need to consider what are the critical ideas of which students need to develop understanding
3. Because new understandings are constructed on a foundation of existing understanding and experiences, we need to consider the essential prior knowledge students
4. Learning complex ideas takes time and often happens as students work on tasks that force them to synthesize, thus it is better to focus on developing integrated understanding of a few key ideas

What should elaborated standards look like?

Information needed to develop effective assessments and instructional materials

Critical subject matter represented by the standard that students should learn and **how** they should be able to use that knowledge

Common alternative ideas students may have regarding the content

Potential difficulties students may have learning the content

Construct-Centered Design (CCD)

A flexible design process that provides a systematic approach for developing a variety of products

- assessments
- instructional materials for students and teachers
- learning progressions

Using this process to develop standards would facilitate the coherent development of products

What is CCD?

Adaptation of aspects of:

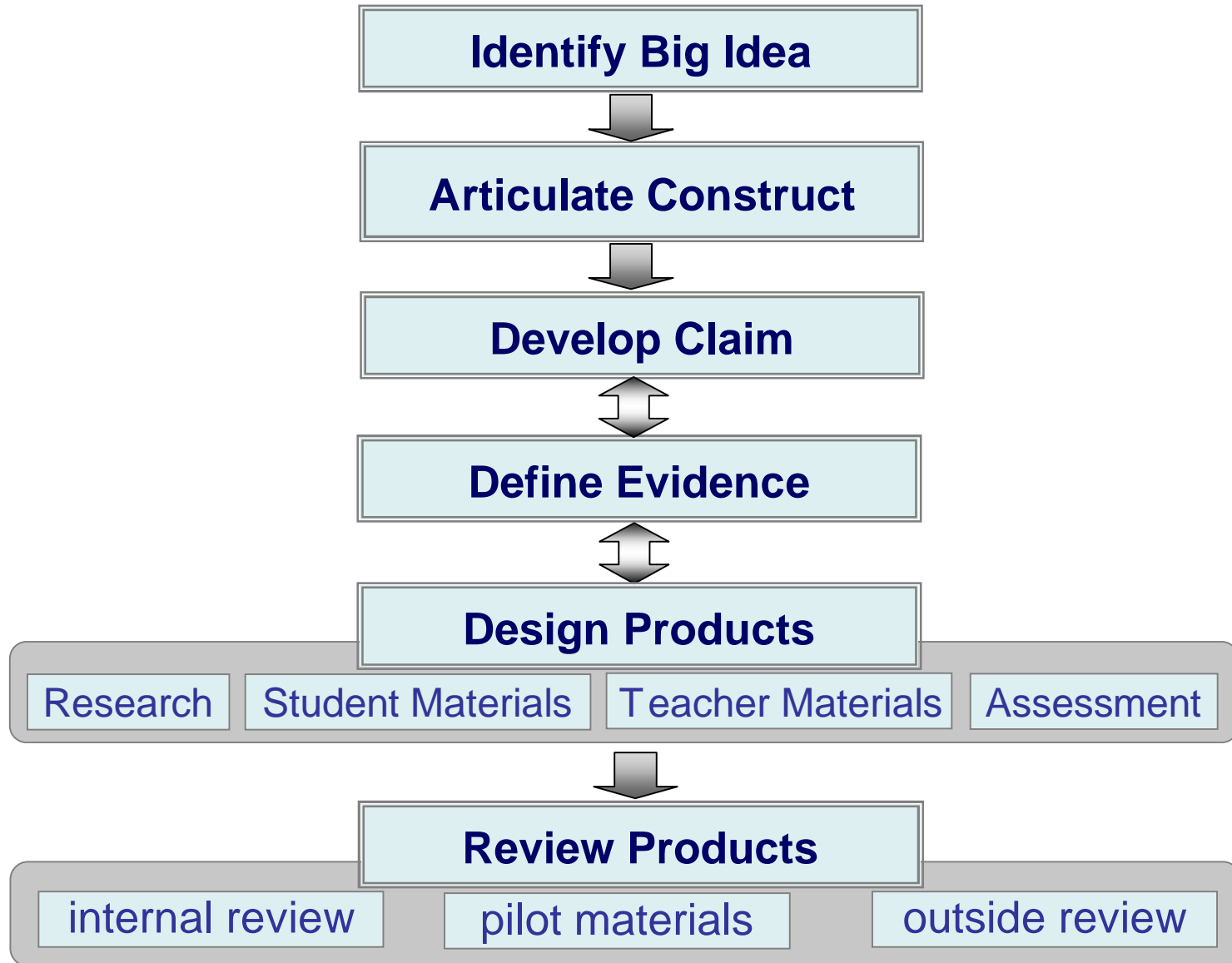
- learning-goals-driven design (Krajcik, McNeill, & Reiser, 2007)
- evidence-centered design (Mislevy, et al., 2003)
- the assessment triangle (Pellegrino, et al., 2001)

Focus on the construct—the ideas and skills students are expected to learn and that teachers and researchers want to measure

- Define knowledge domains (construct)
- Use construct to align development of curriculum, instruction, and assessment

Construct-Centered Design (CCD)

a systematic design process



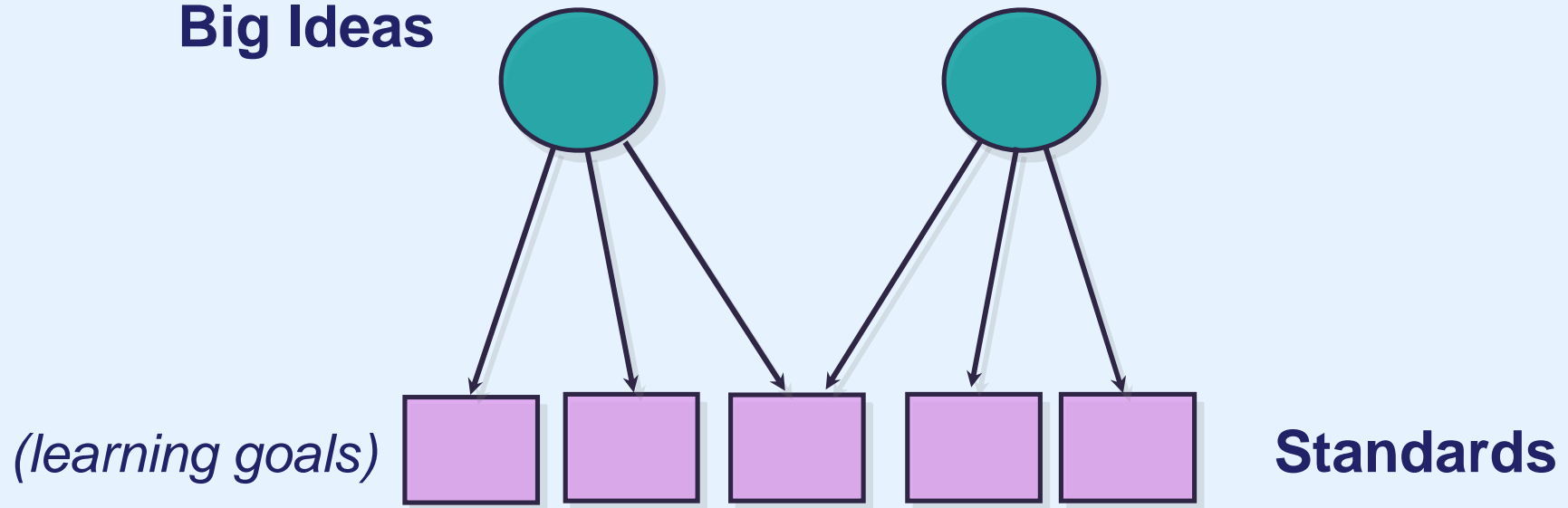
Step 1: Select or Identify the Construct

Big idea

- central concepts, principles, models of the discipline
- provide a framework for relating concepts
- can link to one or multiple disciplines
- help learners to explain a range of phenomena
- overarching themes that cross disciplines
 - Examples: models, size and scale

How do we use big ideas?

Big Ideas

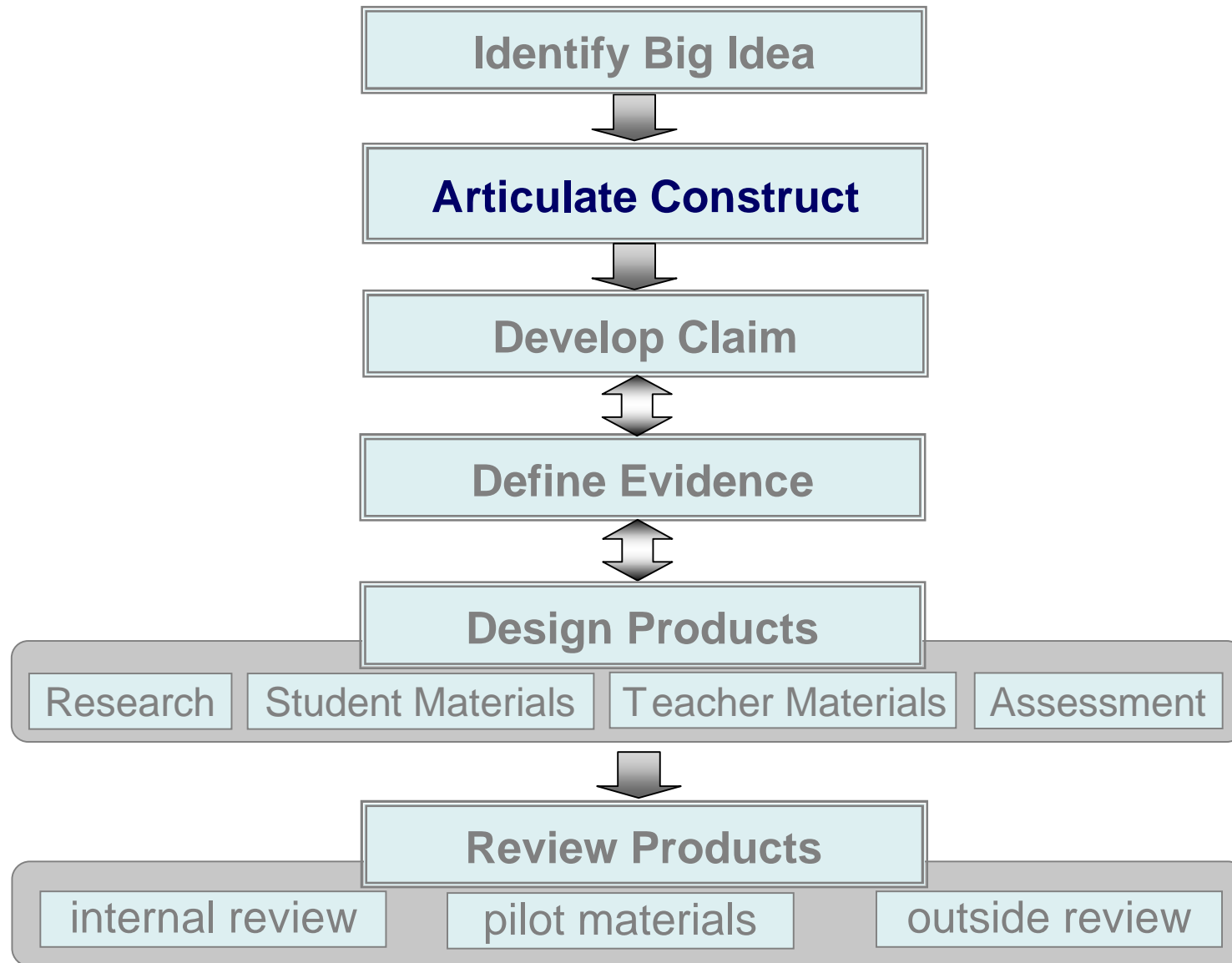


Use big ideas as a framework to organize standards

- build coherence into the standards document
- support development of coherent disciplinary curricula
- provide framework for students to build meaningful understanding of important ideas over time

Construct-Centered Design

a systematic design process



Step 2: Articulating the Construct

Unpacking-

- Explicitly specify all of the content that is necessary to develop understanding of the big idea(s)
 - Includes concepts that are not just related to a big idea, but *necessary for building understanding* of the big idea
- Includes a description of knowledge already held (and needed) by students before beginning to develop understanding of the big idea
 - Informed by learning research
- Prerequisite knowledge
- Potential student difficulties learning the content
- Common alternative ideas

Example of content unpacking

Electrical Forces

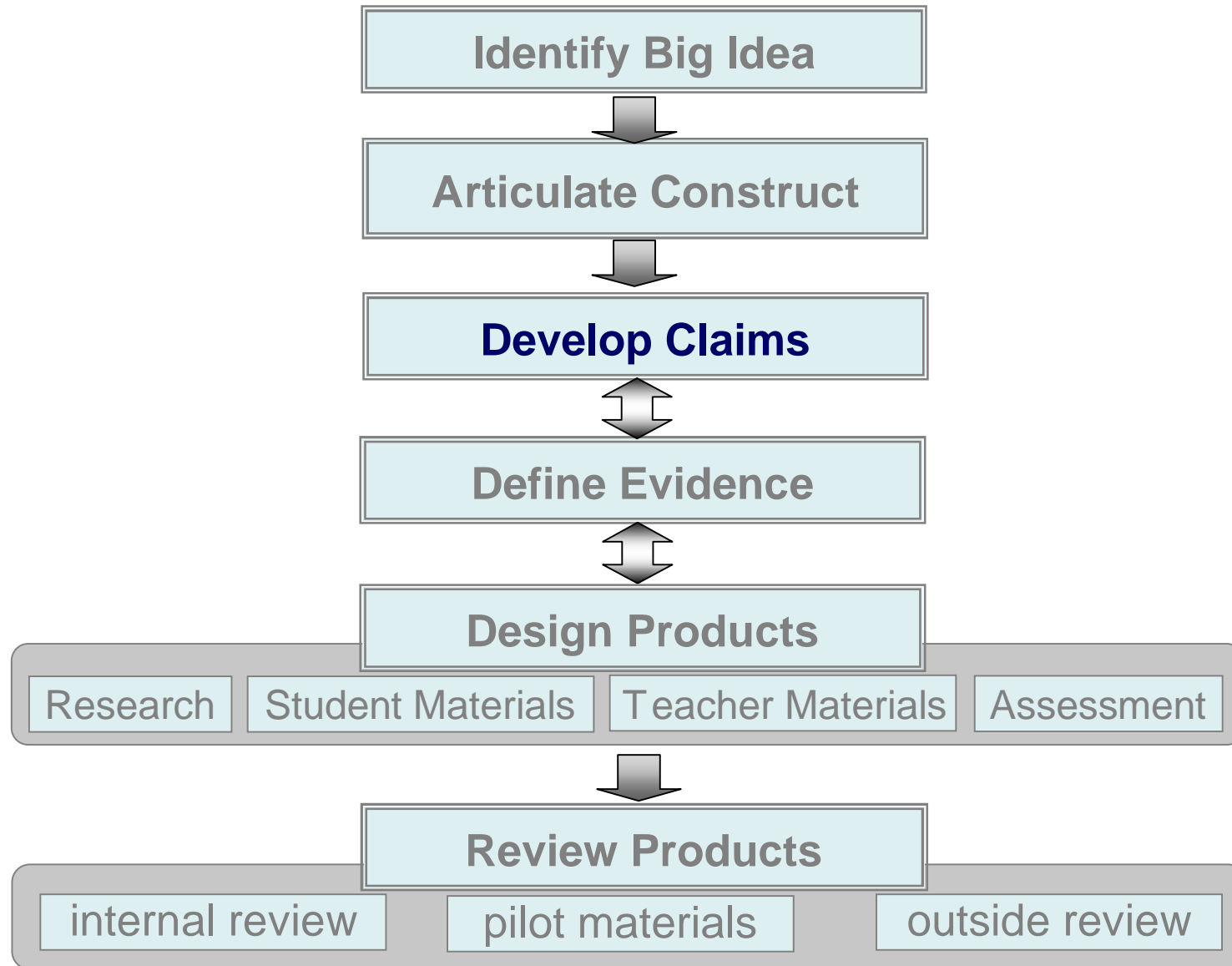
- Electrical forces depend on charge. There are two types of charge—positive and negative. Opposite charges attract; like charges repel
 - The outer shell of electrons is important in inter-atomic interactions. The electron configuration in the outermost shell/orbital can be predicted from the Periodic Table.
 - Properties such as polarizability, electron affinity, electronegativity affect how a certain type of atom or molecule will interact with another atom or molecule. These properties can be predicted from the Periodic Table.
 - Electrical forces generally dominate interactions on the nano-, molecular and atomic scales
 - The structure of matter depends on electrical attractions and repulsions between atoms and molecules
 - An ion is created when an atom (or group of atoms) has a net surplus or deficit of electrons
 - Certain atoms (or groups of atoms) have a greater tendency to be ionized than others
 - A continuum of electrical forces governs the interactions between atoms, molecules and nanoscale objects.
 - The attractions and repulsions between atoms and molecules can be due to charges of integer value, or partial charges. The partial charges may be due to permanent or momentary dipoles.
 - When a molecule has a permanent electric dipole moment, it is a polar molecule.
 - Instantaneous induced dipole moments occur when the focus of the distribution shifts momentarily, thus creating a partial charge. Induced-dipole \square induced-dipole interactions, result from the attraction between the instantaneous electric dipole moments of neighboring atoms or molecules.
 - Induced-dipole \square induced-dipole interactions occur between *all* types of atoms and molecules, but increase in strength with an increasing number of electrons.
 - Polarizability is a measure of the potential distortion of the electron distribution. Polarizable atoms and ions exhibit a propensity toward undergoing distortions in their electron distribution.
 - In order to predict and explain the interaction between two entities, the environment must also be considered
-

Potential student ideas and difficulties

- Students often consider only the interacting entities and forget to consider interactions with the particles in the environment
- Students have difficulty applying the concept of polarity (Taber & Coll, 2002)
- Students often rely too heavily on the octet model to explain interatomic interactions (Taber & Coll, 2002)
- Students may believe that bond polarity is a secondary property of covalent bonds instead of thinking about a continuum between ionic and covalent bonding (Pallant & Tinker, 2004)
- Students may believe that charge-charge interaction results in neutralization, not bond formation. (Boo 1998; Pallant & Tinker, 2004)
- Students often do not know the forces responsible for holding particles together in the liquid or solid state (Stevens, et al., 2007)

Construct-Centered Design

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Step 3: Developing claims

- A claim involves the knowledge students have and what they should be able to do with it
- Incorporates both content and cognitive skills
- Uses descriptive and specific verbs to clarify performances expectations. For example:
 - describe, analyze, compare and contrast, design
 - explain phenomenon using evidence and reasoning
 - build and describe models

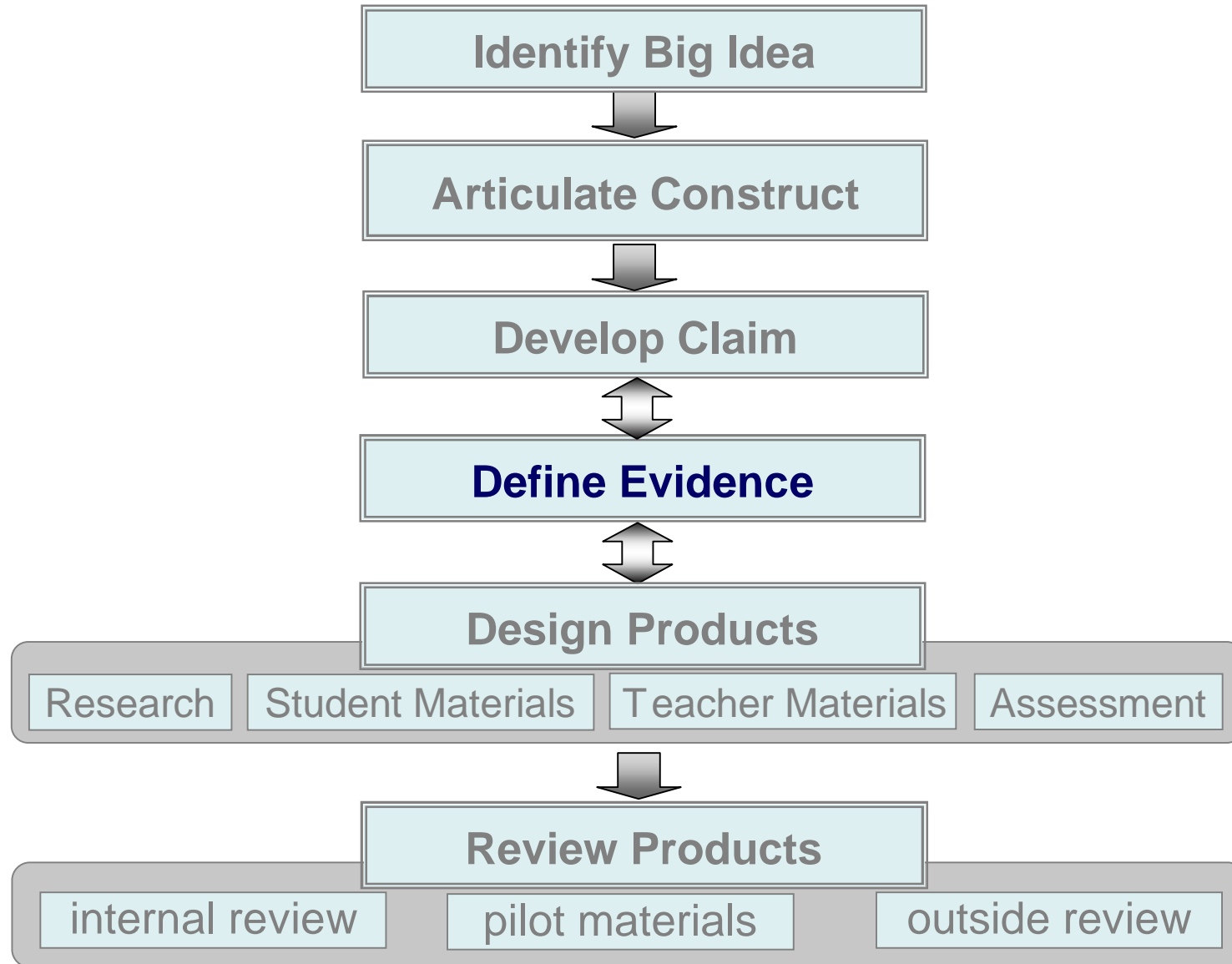
An example claim

Related to the unpacked content for electrical forces

Claim: *Students should be able to explain the attraction between two objects in terms of the generation of opposite charges due to imbalance of electrons.*

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Step 4: Define Evidence

What will you accept as evidence in support of a claim that a learner has the desired knowledge and skills?

- Specific learner performances and/or work products that you would accept as indicative that a claim has been satisfied.
- The features of students' work products and performances that you expect to see and their value and importance in supporting a claim

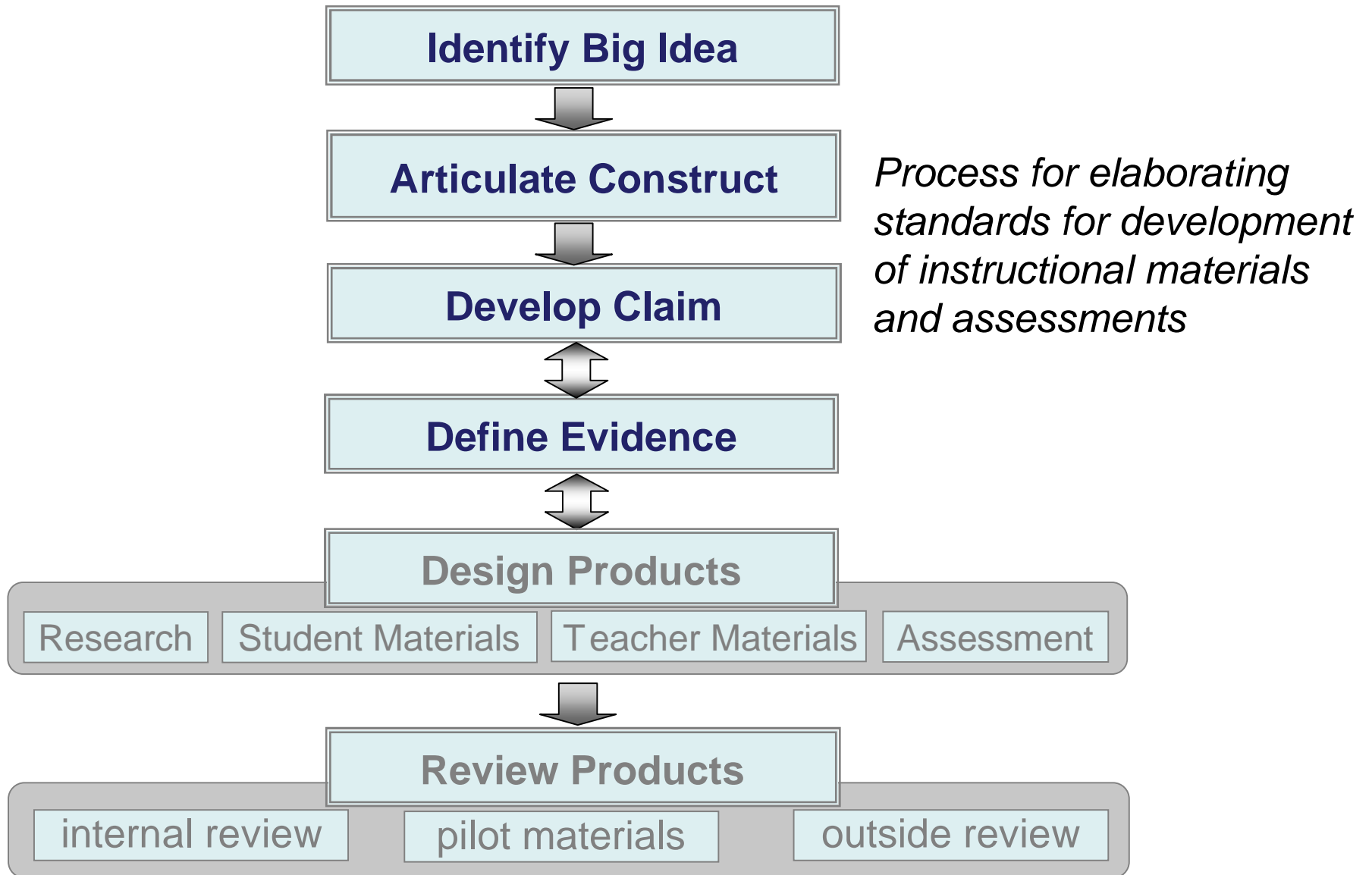
Evidence associated with the claim

Claim: *Students should be able to explain the attraction between two objects in terms of the generation of opposite charges due to imbalance of electrons.*

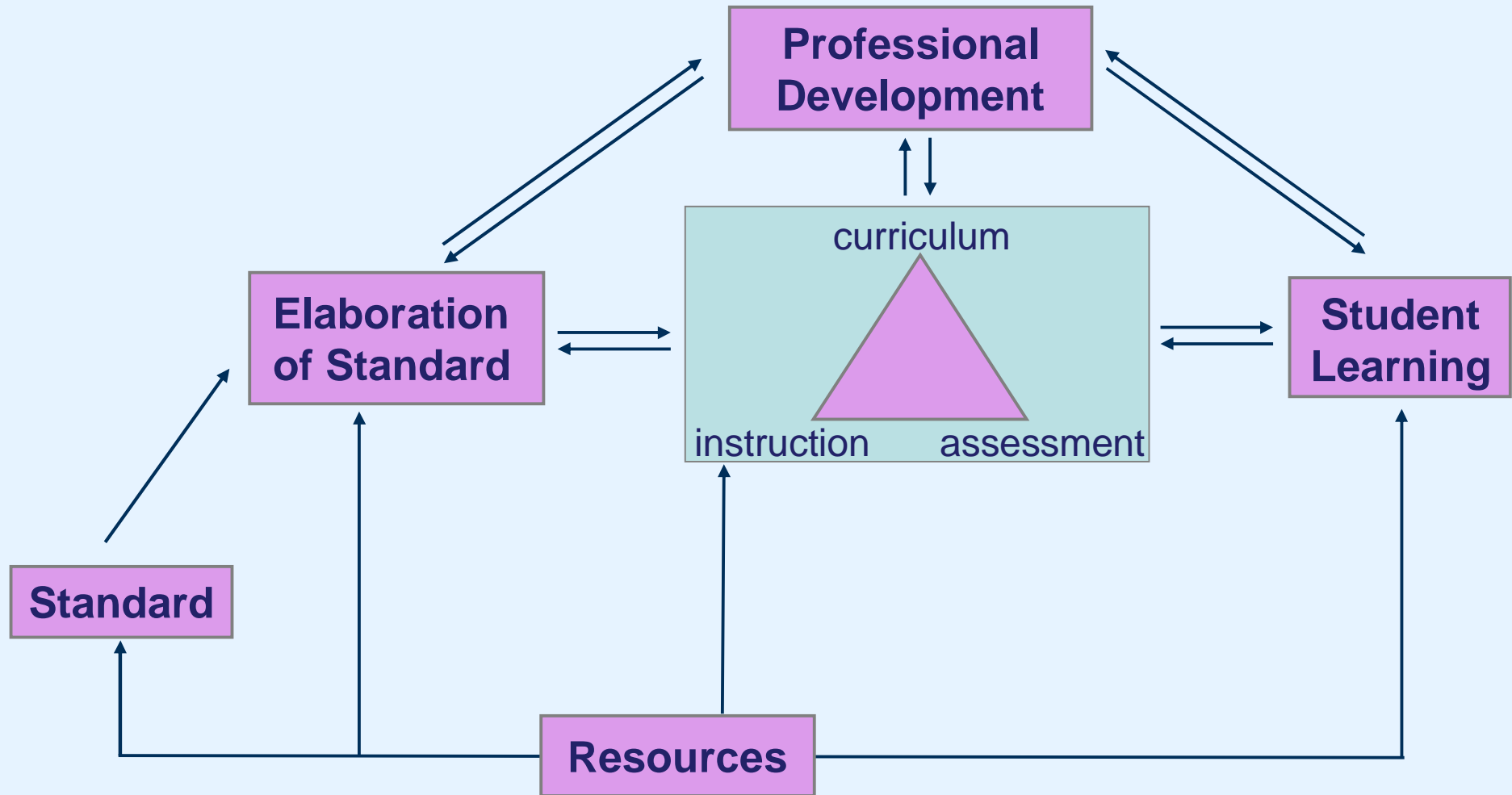
In their explanations, students will :

- explain the production of charge by noting that only electrons move from one object to another object
- note that neutral matter normally contains the same number of electrons and protons
- note that electrons are negative charge carriers and that the destination object of the electrons will become negative, as it will have more electrons than protons
- recognize that protons are positive charge carriers and that the removal of electrons causes the remaining material to have an imbalance in positive charge
- cite the opposite charges of the two surfaces as producing an attractive force that hold the two objects together.

Construct-Centered Design



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Specifying Standards

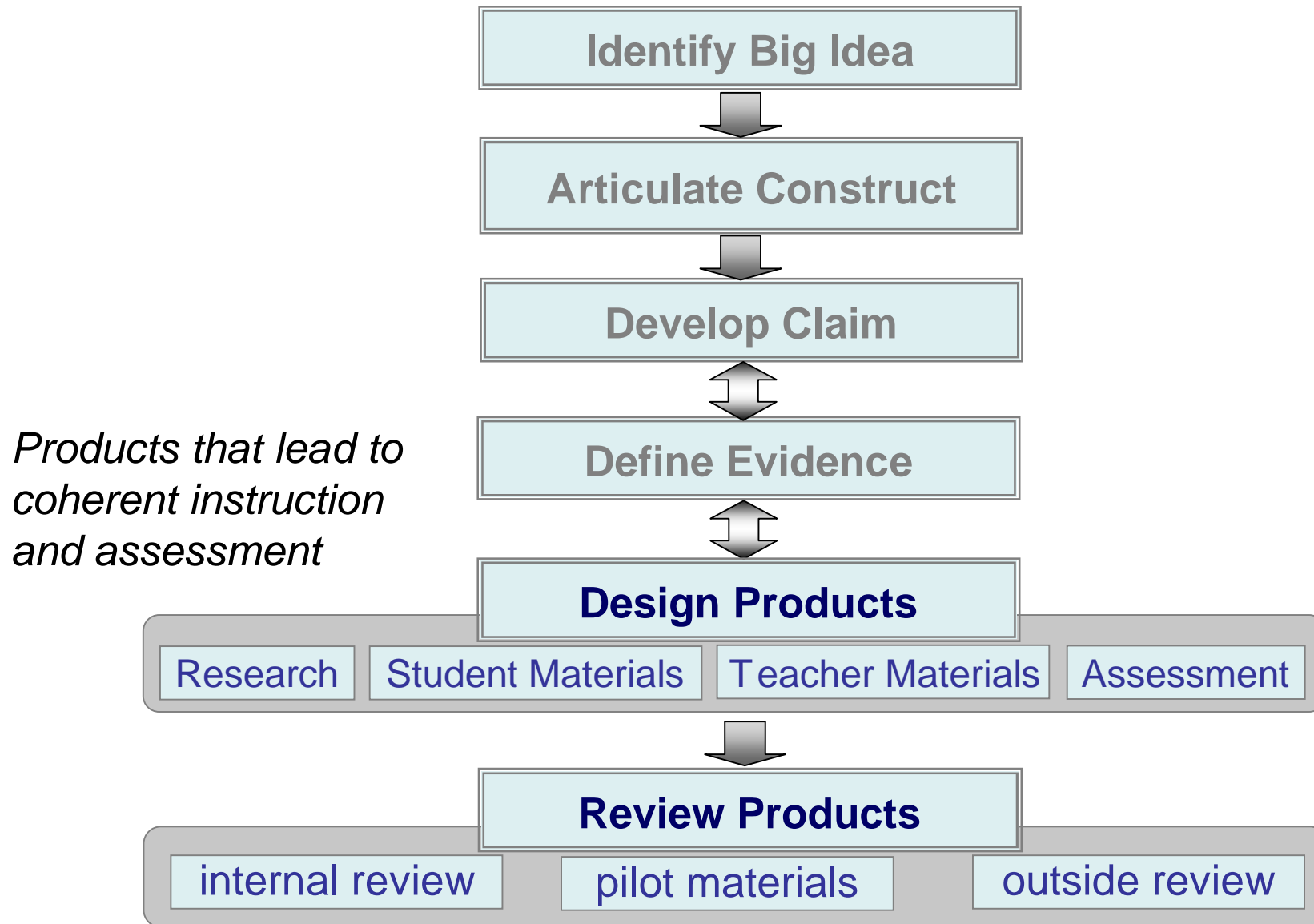
Standards specified based on the products of the first four steps of CCD

- Unpacking content identifies concepts **critical** for developing meaningful understanding of the big idea
- The claims clearly illustrate **how** students should be able to use the knowledge
- Carefully specifying evidence links back to the critical content and defines different levels as learners build understanding of the big idea over time

Facilitates development of coherent assessments and instructional materials

Construct-Centered Design

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Step 5: Design Products

(assessment and learning 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

Claim and evidence

Claim: *Students should be able to explain the attraction between two objects in terms of the generation of opposite charges due to imbalance of electrons.*

In their explanations, students will :

- explain the production of charge by noting that only electrons move from one object to another object
- note that neutral matter normally contains the same number of electrons and protons
- note that electrons are negative charge carriers and that the destination object of the electrons will become negative, as it will have more electrons than protons
- recognize that protons are positive charge carriers and that the removal of electrons causes the remaining material to have an imbalance in positive charge
- cite the opposite charges of the two surfaces as producing an attractive force that hold the two objects together.

Assessment and learning tasks

Learning Task:

Students predict how pieces of tape will be attracted or repelled by each other and test their predictions.

Assessment Task:

Students are asked to explain why the rubbing of fur against a balloon causes the fur to stick to the balloon.

Step 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

Modeling standard from CCSSO and National Governor's Association

Core concepts Students understand that:

- A- Mathematical models involve choices and assumptions that abstract key features from situations to help us solve problems
- B- Even very simple models can be useful

Core skills Students can and do:

- 3- Model situations with equations and inequalities.
Include situations well described by a linear inequality in two variables or a system of linear inequalities defining a region in the plane.

Well-defined boundaries of content for particular level

Writing standard from CCSSO and National Governor's Association

Standard 4 of *Core Standards for Writing*

- Making an argument
- Informing or explaining

“Support and illustrate arguments and explanations with relevant details, examples, and evidence”.

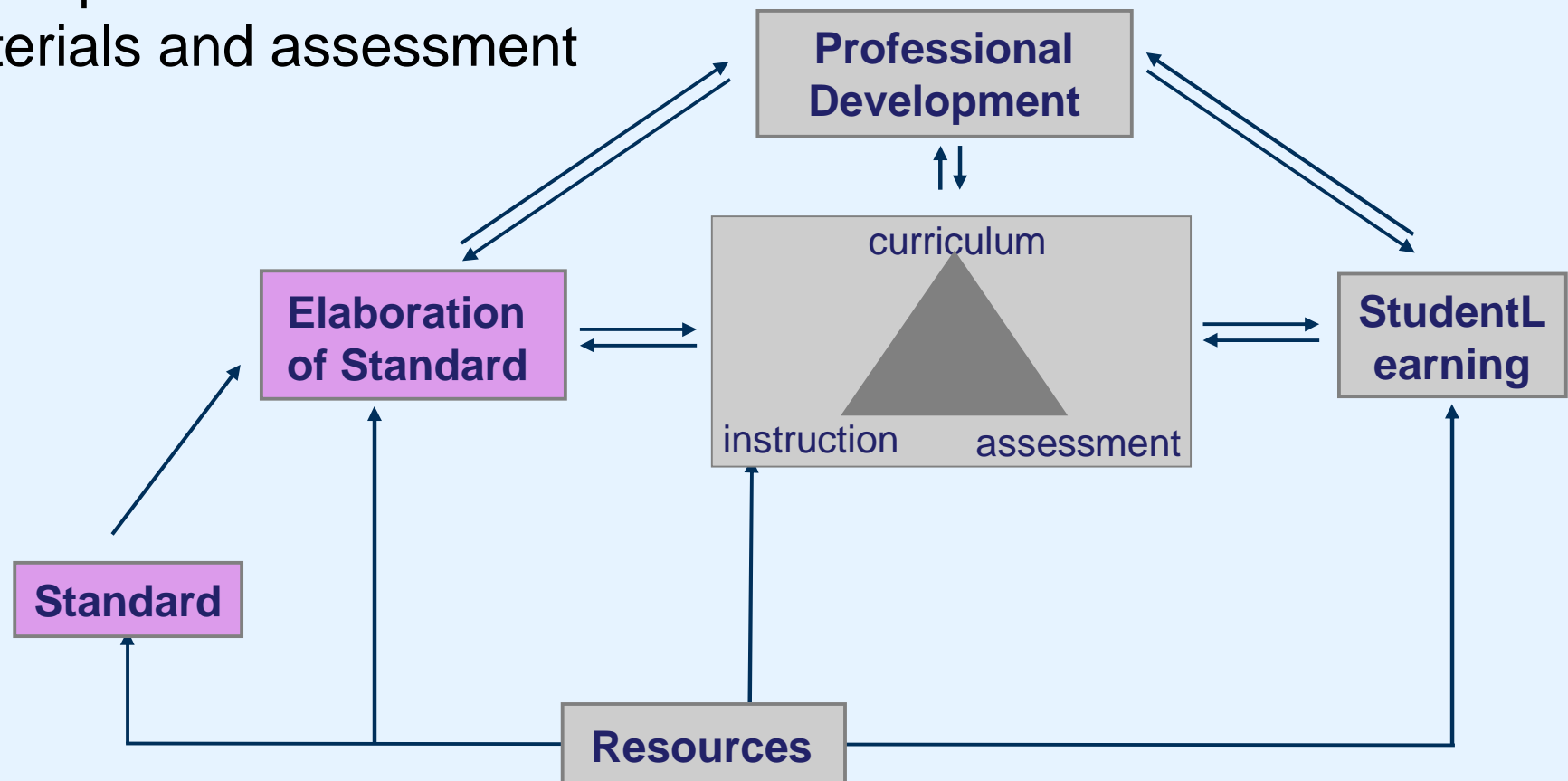
“When writing arguments, students must also do the following:

16. *Establish a substantive claim, distinguishing it from alternate or opposing claims.*
17. *Link claims and evidence with clear reasons, and ensure that the evidence is relevant and sufficient to support the claims.”*

Comments on a writing standard

- Need to specify how learners at different levels might perform the task of creating an argument
- Link to various disciplines and differentiate what evidence means for each
- Practice linked closely to content
 - *How do we clearly specify evidence for this type of important learning goal?*

In comparison to declarative statements about content, elaboration of standards facilitates coherence of curriculum and development of instructional materials and assessment



(Adapted from *Systems for State Science Assessment*, NRC, 2006)

Summary

Using CCD or similar process:

- identifies and specifies concepts critical for developing meaningful understanding of the big idea
- uses claims clearly illustrate the learning expectations for students—how students should be able to use the knowledge
- specifies evidence to support the claims, providing a clear and coherent guide for assessment and instructional materials developers

Organizing standards around big ideas:

- supports development of coherent curriculum
- creates a framework that describes how students can develop meaningful understanding of important ideas over time.

Acknowledgements



*UM-Learning
Progression*

NCLT

