Learning Goals & Objectives for Computational Physics

Danny Caballero
- Department of Physics and Astronomy
Michigan State University
- Department of Physics and Center for Computing in Science Education
University of Oslo

Larry Engelhardt
-Department of Physics and Engineering
Francis Marion University

Kelly Roos
-Department of Mechanical Engineering
Bradley University

PICUP

- Adapted (by Danny) from SEI Learning Goals Workshops at CU Boulder
- Adapted (by Larry) for a shorter session
- Adapted (by Kelly) for an even shorter session

Common Protests to Integrating Computational Activities Into "Perfectly Good" Physics Courses

1. Will take valuable time away from the fundamentals that need to be covered
   (something important would have to be left out)

2. Don't want to make this a programming course

3. Too difficult and beyond the scope of undergraduate physics education.

4. Tradition!?

5. Computational subject matter, and examples, not in text books

6. Don't have time to invest to develop course materials and exercises

7. Don't have sufficient computational background

8. Other

Learning goals for today

You will be able to:

- Appreciate the value of developing learning goals
- Develop and communicate your learning goals clearly for your course as a whole, and for a particular topic
- Recognize the value of aligning assessments with goals
- Begin writing learning goals specific to computation

General Overview

- First half: Discussing & thinking about learning goals/objectives in general
- Second half: You will start to think about, and write down, your own learning goals as they relate to computation

CASE STUDY:
The Frustrated Student

goo.gl/RXf3AQ

I am a sophomore majoring in physics. I was thinking I might go to graduate school to do research and become a professor, or maybe apply for an industrial internship. I usually get As in my courses, only a few B's so far in college. I totally breezed through high school, it was so easy.

This semester, I enrolled in Modern Physics. I approach this class like most others: I attend lecture (have only missed two), read the textbook (usually before class), and turn in the homework if it's going to be graded. Prof. Garcia is great; he's really well organized and follows the book closely. The homework has been helpful for learning the terms and information.

The first midterm exam in this course was NOT what I expected. None of the questions were multiple choice. We had to write out short (and sometimes LONG) answers. I barely finished it in the 2-hour exam period. Plus, three of the questions tested us on things we had never learned and skipped stuff we had covered in class. For example, we learned about delta functions, and it wasn't even on the test. But there was this question asking us which observations from the photoelectric effect are inconsistent with a particle theory of light. How am I supposed to know about that? I got a 55 on that test. What a crock! Forget physics, it's not for me.

Adapted from Handelsman, et al.

CASE STUDY:
Frustrated Student

goo.gl/RXf3AQ

Quick discussion

- What issues might be contributing to this situation?
  - In the assessments? In shared understanding of expectations?
- What suggestions do you have for the professor?

An issue…

We do not always design for what we value.

AND

There is a huge disconnect
between how students see the course and how we do.
(They operate in a different reality!)

So…it's critical to be explicit about
purpose and expectations.

Teacher Centered Approach

Identify topics to "cover" in the course

What topics do ***I*** *need to teach my students?*

Create the syllabus and lecture slides

When will ***I*** teach the topics? How will ***I*** give them the information?

Write exam questions

How will ***I*** know that students learned the material ***I*** covered?

Learner Centered Approach

Identify learning goals/objectives → **Decide on assessments** → **Create activities and syllabus**

How will my ***students*** *be different?*

What evidence will ***students*** provide that they have changed?

What do ***students*** need to achieve those goals?

“Twin sins” of traditional course design

“Hands-on without minds on”

engaging without a clear purpose

“Coverage”

traversing all factual material within a textbook or topic = learning

An old adage:

"If you don't know exactly where you are headed, then any road will get you there."

Wiggins and McTighe, "Understanding by Design" 1998:

"How will we distinguish *merely interesting* learning from *effective* learning?"

"Good design is about learning to be more *thoughtful and specific* about our purposes and what they imply."

For instruction to be effective…

- Lessons should be logically inferred from the results sought, not created without the results in mind

- Curriculum should lay out effective ways of achieving results, and these should be transparent to students

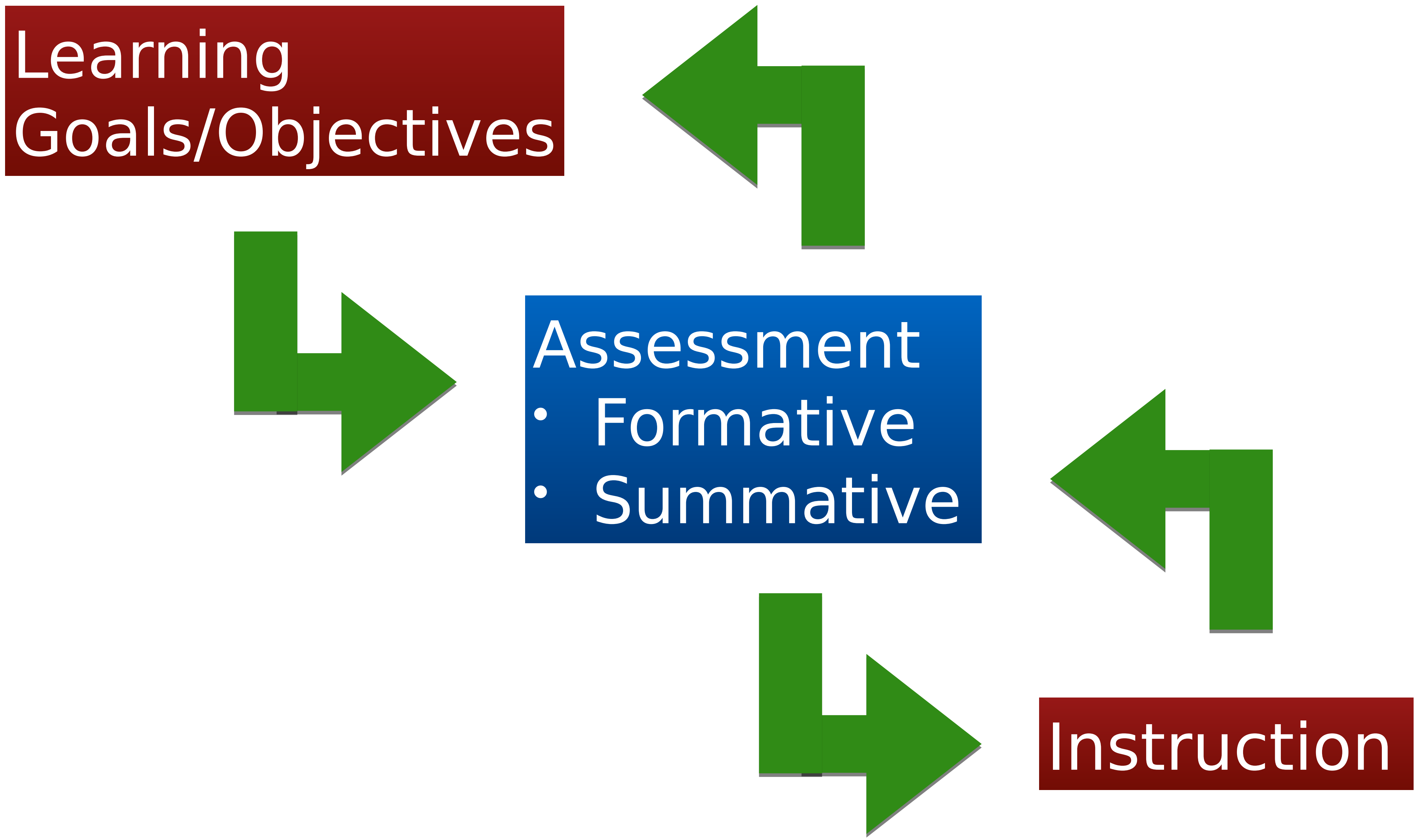
(i.e. Backward Design)

Backward Design

What should students know or be able to do by the end of the course/ session?

What evidence will convince you that they got there?

How will you help them get there?


Learning Goals/Objectives
Assessment
• Formative
• Summative
Instruction

Terminology

- **Learning goal:** Broad description of what students will understand and learn: often COURSE LEVEL (usually 5-10 per course)

- **Learning objective:** specific, action-oriented description of what students will be able to do: often CLASS LEVEL (usually 2-5 per topic)

This is not just a list of the syllabus topics, but statements of what students can do as a result of learning about the topic.

Example of Learning Goal vs. Learning Objective

Course learning goals	Topic-level learning objective
Students will understand the basic concepts of probability and random variables	Students will be able to: • Explain probability in terms of long-term relative frequencies • Find probabilities of single and complementary events • Calculate the mean and variant of a discrete random variable

Credit: UBC CWEI, www.cwsei.ubc.ca Stat 200

Example of Learning Goal vs. Learning Objective

Course learning goals	Topic-level learning objective
Students should see the various laws in the course as part of the coherent field theory of electromagnetism; ie., Maxwell’s equations	Students should be able to: • Interpret the third and fourth Maxwell’s equations for electrostatics (divergence and curl of B), and u • Use them to describe magnetostatics (i.e., Ampere’s Law and Biot-Savart law are just applications of these laws).

Credit: Michigan State University, PHY 481

Activity: Develop course-scale goals for computation

In small groups, write down a few course-scale learning goals for a canonical physics course that form the driving goals of using computation in that course.

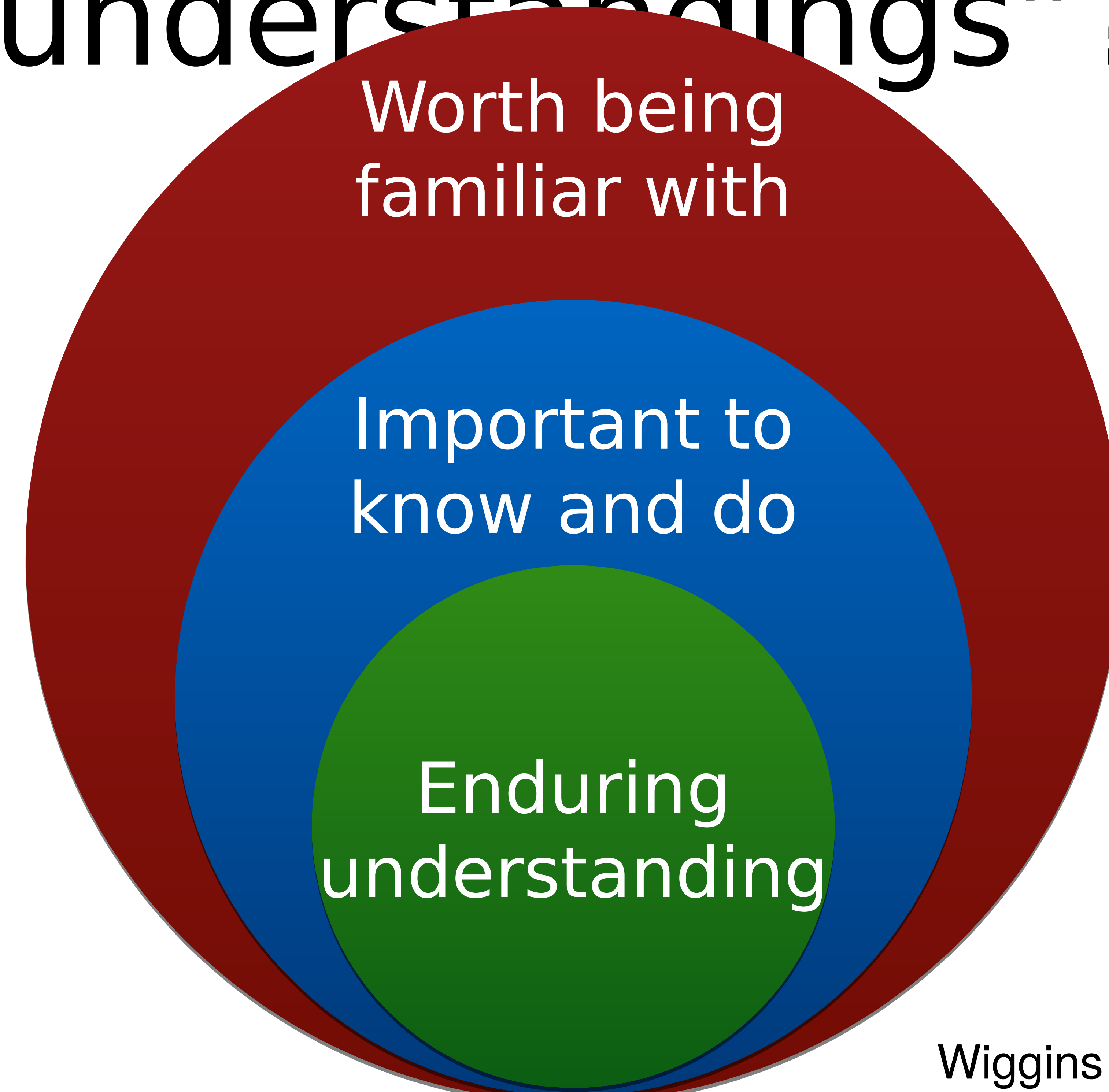
Work in pairs or small groups to do this.

You may work on a course at any level.

Sharing what you have…

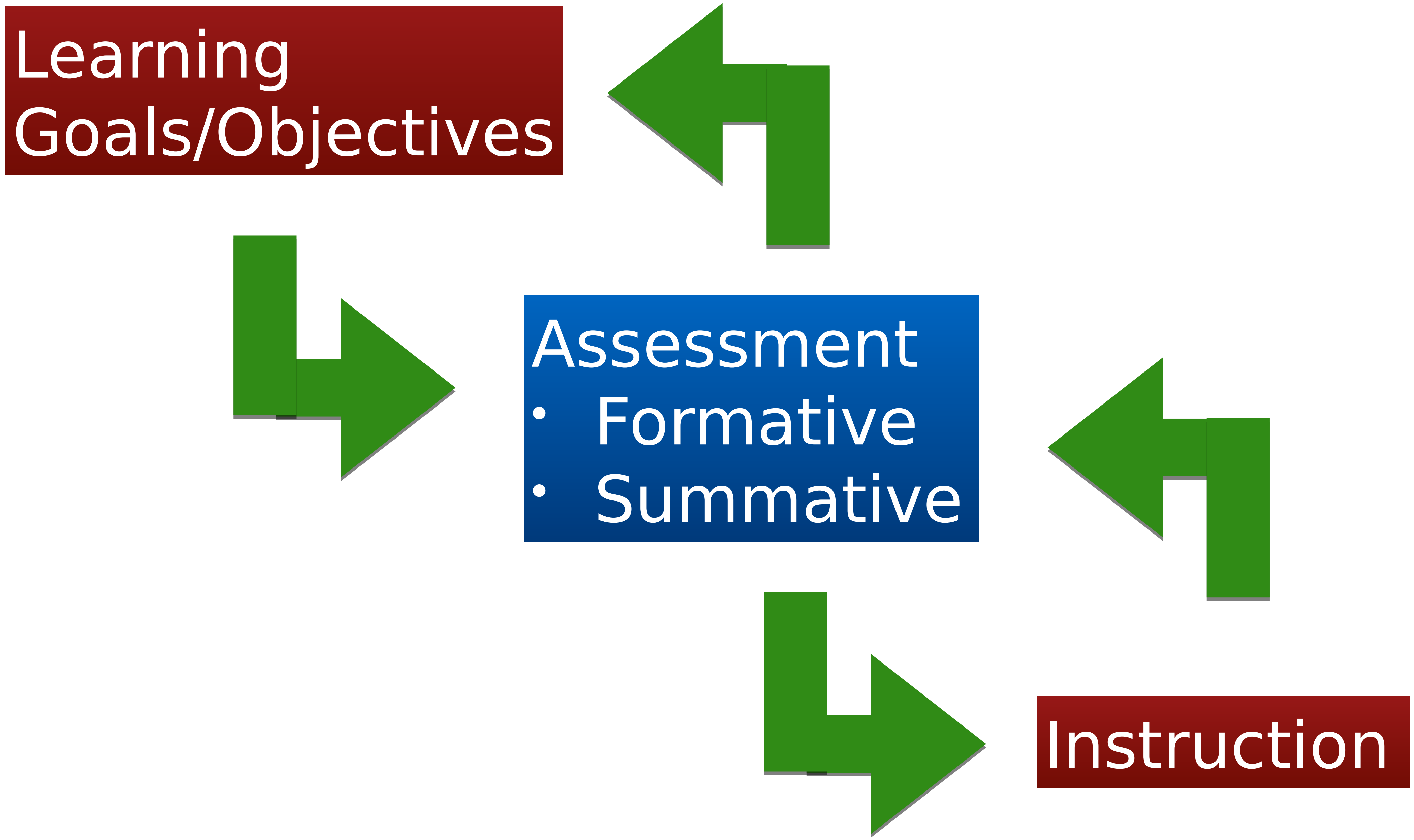
5 Minutes

Do your goals represent “enduring understandings”?



Wiggins and McTighe, 1998

Remember – this is just part of the process, you then need to align assessments & instruction



Look at your course goals

- Is anything missing? Certain types of knowledge that are also important?

- How would students demonstrate success (assessment)? How might they achieve these goals (instructional activities)?

5 Minutes

Now let's look at topic-level learning objectives...

- **Learning goal:** Broad description of what students will understand and learn : often COURSE LEVEL (usually 5-10 per course)

- **Learning objective:** specific, action-oriented description of what students will be able to do: often CLASS LEVEL (usually 2-5 per topic)

This is not just a list of the syllabus topics, but statements of what students can do as a result of learning about the topic.

Write Learning Objectives

With a partner or small group, write learning objectives for a specific computational physics topic.

Consider only a single lesson (could be a class meeting, activity, lab, etc.)

5 Minutes

Check-list for refining **topic-scale** learning objectives:

- Is goal expressed in terms of **what the student will achieve** or be able to do?
- Is the goal **well-defined?** Is it clear how you would measure achievement?
- Do chosen verbs have a **clear** meaning?
- Is **terminology familiar**/common? If not, is the terminology itself a goal?
- Does the goal **align** with course-scale goals?
- Do your goals cover a range of types of knowledge?
- Is it relevant and useful to students?

5 Minutes

Now what?

- When would you write your learning goals?
- When do you refer to your written learning goals?
- How would you use these to streamline your course content?
- What are some pitfalls and troublespots?

Communicate your learning goals

Students appreciate knowing the explicit expectations of them.

It helps them focus their effort.

e.g., dannycab.github.io/teaching/phy481_lgs.html

How well did you achieve today's learning goals?

You will be able to:

- Appreciate the value of developing learning goals
- Develop and communicate your learning goals clearly for your course as a whole, and for a particular topic
- Recognize the value of aligning assessments with goals


WARNING
INITIAL TRY
MAY NOT PRODUCE
DESIRED OUTCOME

Questions/ Comments?

dannycab.github.io
caballero@pa.msu.edu
@physicistdanny

lengelhardt@fmarion.edu