BEST PRACTICES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) IN CAMBODIAN HIGHER EDUCATION INSTITUTIONS

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Summary of today's agenda

- Wednesday, 16 October
  - Developing learning objectives for your course
  - Assessing students' learning
  - Constructing a syllabus using learner-centered methods

DEVELOPING LEARNING OBJECTIVES FOR YOUR COURSE

Teaching-centered versus Learning-centered instruction (A review)

Concept	Teacher-Centered	Learner-Centered
Teaching goals	• Cover the discipline	Students learn: • How to use the discipline • How to integrate disciplines to solve complex problems
Course structure	• Faculty cover topics	• Students master learning objectives
How students learn	• Listening • Reading • Taking and passing exams	• Students construct knowledge • Integrate new learning into old • Learning is a cognitive and social act
Pedagogy	• Based on delivery of information	• Based on engagement of students

Developing learning objectives for your course

1. Ask yourself: what is it that you want your students to know or to be able to do as a result of taking this class?

2. Reflect on your level of expertise and what is the level of expertise of your students

3. Develop learning objectives that are assessable

Developing learning objectives for your course

1. Ask yourself: what is it that you want your students to know or to be able to do as a result of taking this class?

Improve practice

Integrate different ideas

Apply knowledge to different circumstances

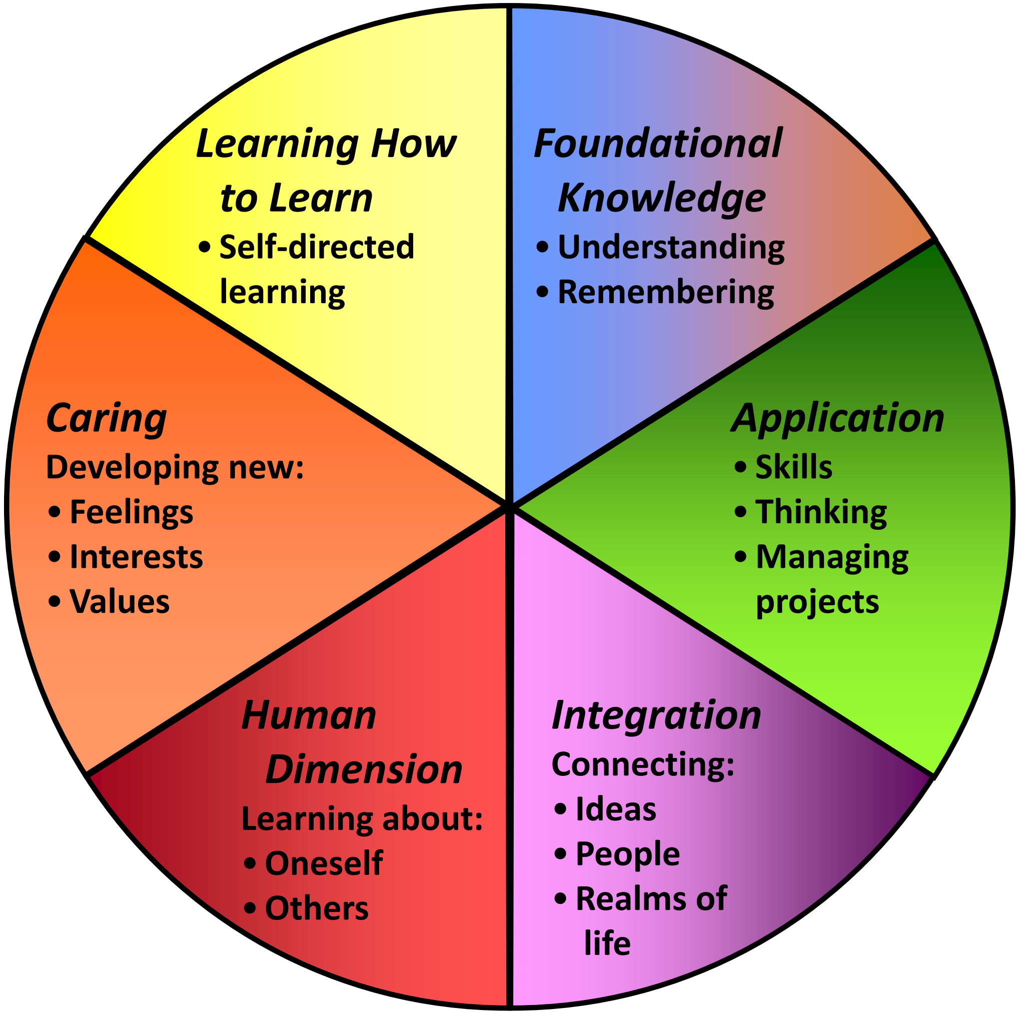
Solve complex problems

Critically analyze an argument or theory

Developing learning objectives for your course

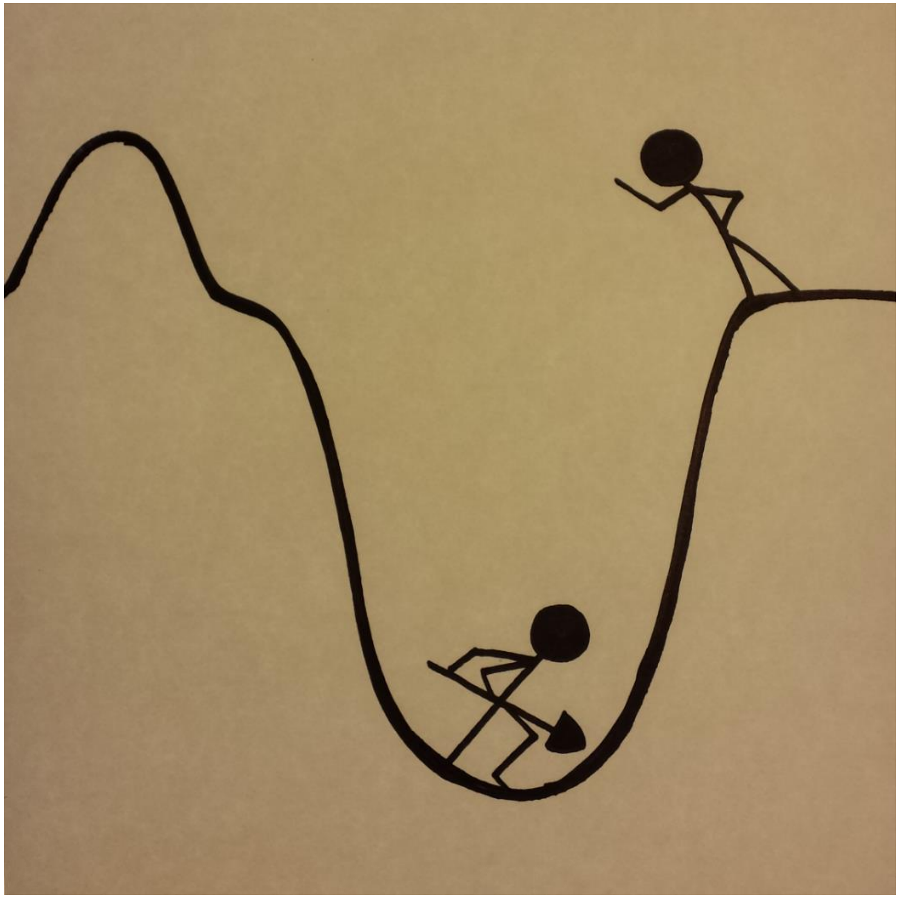
- Also ask yourself:
  - 3 to 5 years from now, when these students will be out in the workforce, what do I want these students to still:
    - Know
    - Be able to do
    - Find value in?

Fink's Significant Learning Goals



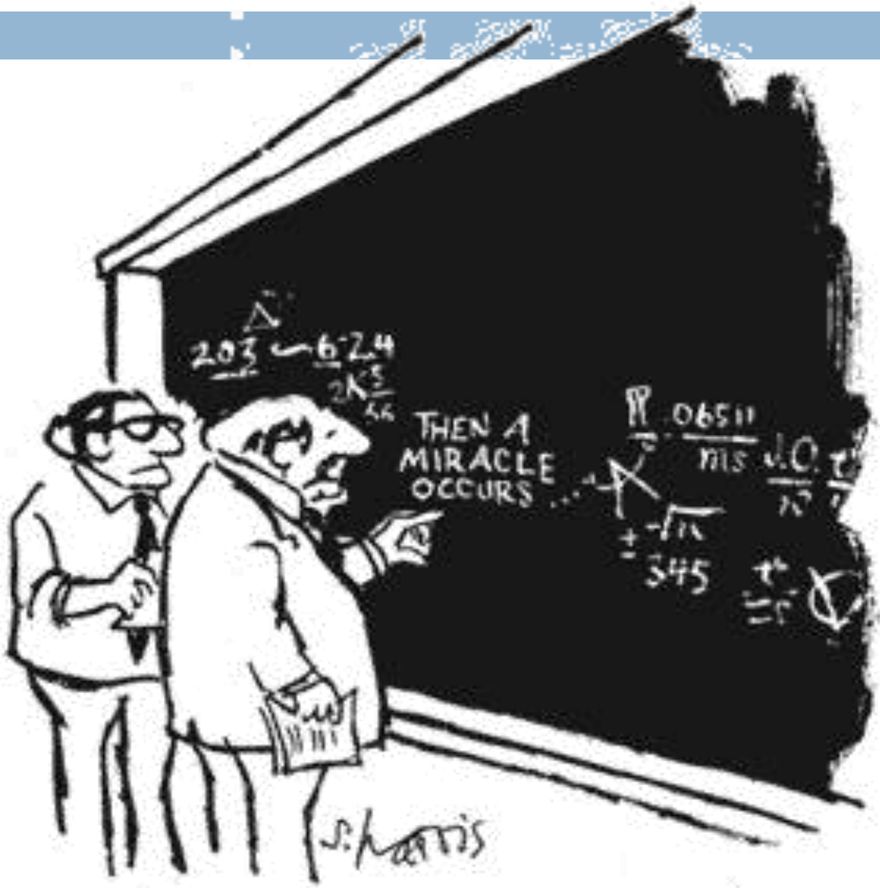
Developing learning objectives for your course

2. Reflect on your level of expertise and what is the level of expertise of your students



Developing learning objectives for your course

3. Develop learning outcomes that are assessable



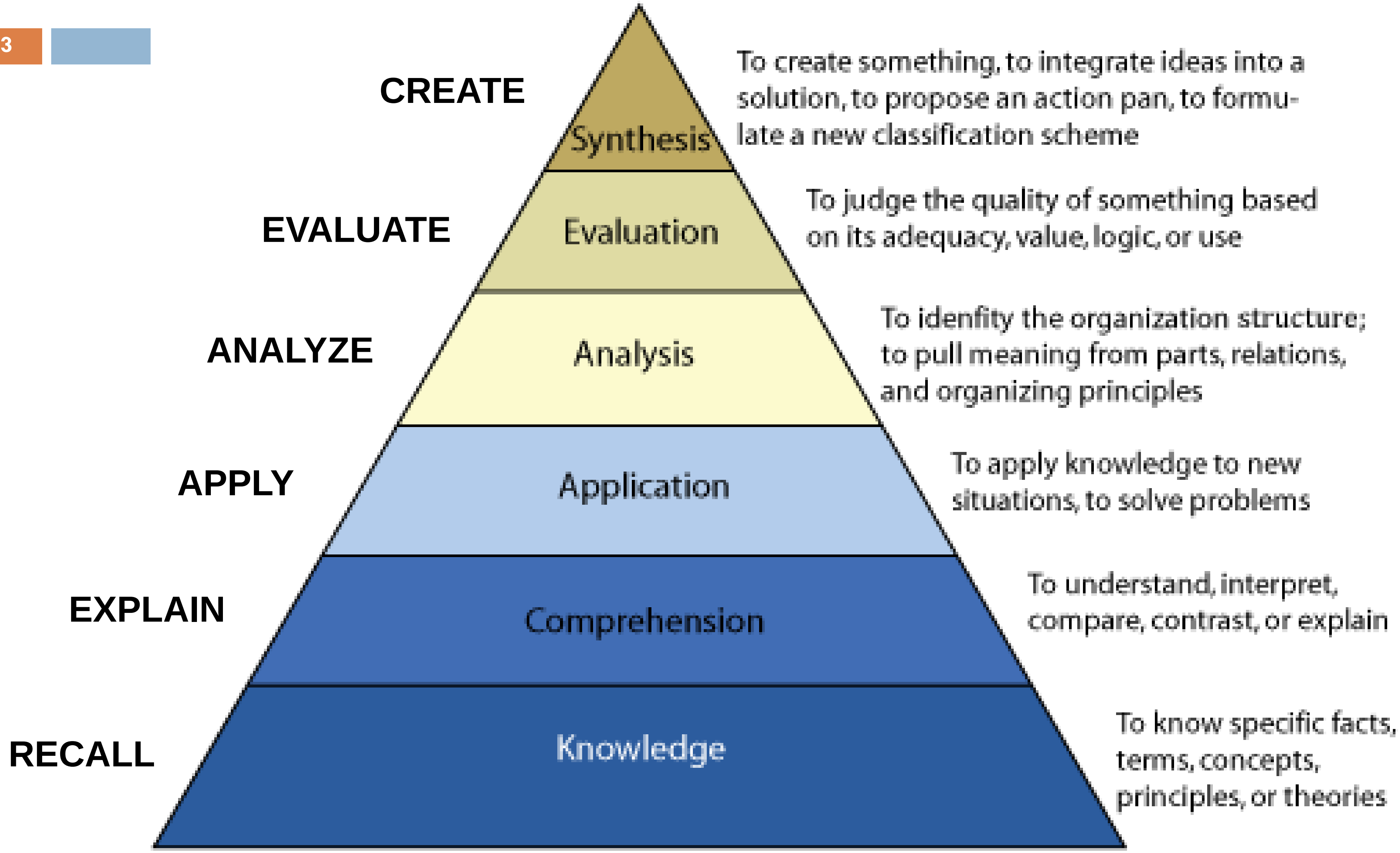
"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Discussion

- THINK-PAIR-SHARE:
  - ✓ Think to yourself and develop 2 or 3 learning objectives for a course that you teach.
  - ✓ Pair with the person next to you, tell him/her your learning objectives, and let that person critique your learning objectives
  - ✓ 3 or 4 can share with the audience

ASSESSING STUDENTS' LEARNING

Bloom's Revised Taxonomy

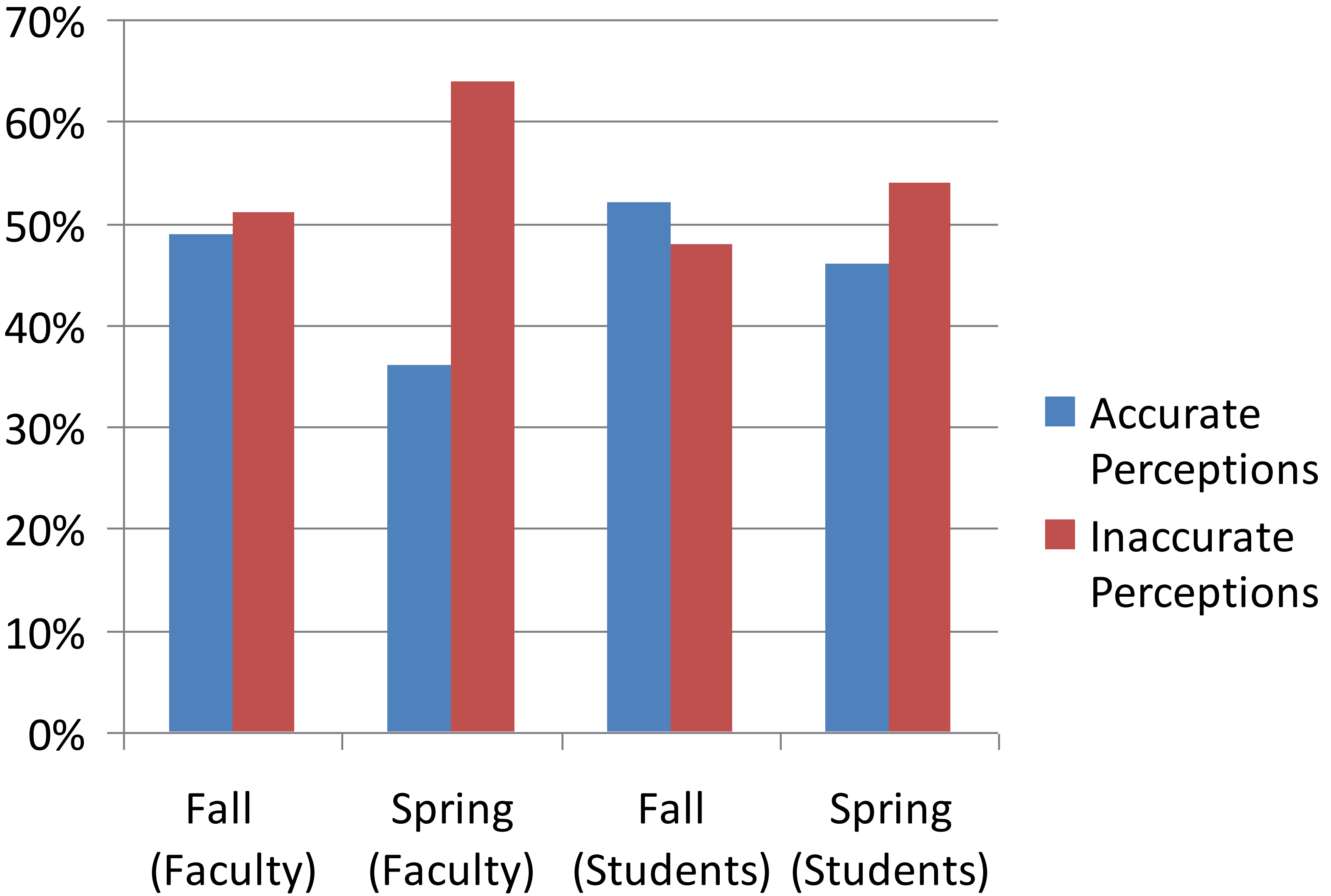


Krathwohl, 2002

Bloom's revised taxonomy action verbs

Knowledge	Comprehension	Application	Analysis	Evaluation	Synthesis
Arrange Define Describe Identify Label List Match Name Recognize Recall Repeat Reproduce Select	Classify Discuss Distinguish Explain Extend Generalize Give example(s) Infer Paraphrase Summarize	Apply Compute Demonstrate Dramatize Employ Manipulate Operate Produce Show Solve Use	Analyze Appraise Categorize Compare Contrast Criticize Differentiate Distinguish Examine Experiment Test	Assess Conclude Defend Discriminate Evaluate Judge Justify Rate Support	Compose Construct Create Design Develop Devise Formulate Generate

Perceptions vs. Performance



DEVELOPING EFFECTIVE RUBRICS

Constructing an evaluation rubric

Constructing an evaluation rubric

CRITERIA				
Hypotheses have scientific merit				
Experimental design is likely to produce salient and fruitful results (tests the hypotheses posed).				

Constructing an evaluation rubric

← EVALUATION LEVELS →

CRITERIA	0 Unsatisfactory	1 Developing	2 Proficient	3 Accomplished
Hypotheses have scientific merit				
Experimental design is likely to produce salient and fruitful results (tests the hypotheses posed).				

Examples of evaluation levels

0	1	2	3
Novice	Apprentice	Proficient	Expert
Unacceptable	Needs improvement	Good	Excellent
Unsatisfactory	Satisfactory	Commendable	Exemplary
Unacceptable	Developing	Proficient	Accomplished

Constructing an evaluation rubric

← EVALUATION LEVELS →

CRITERIA	0 Unsatisfactory	1 Developing	2 Proficient	3 Accomplished
Hypotheses have scientific merit	Hypotheses are trivial, obvious, incorrect or completely off-topic.	Hypotheses are plausible and appropriate through likely or clearly taken directly from course material.	Hypotheses indicate a level of understanding beyond the material directly provided to the student in the lab manual or coursework.	Hypotheses are novel, insightful, or actually have the potential to contribute to useful new knowledge to the field.

Constructing an evaluation rubric

← EVALUATION LEVELS →

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Experimental design is likely to produce salient and fruitful results				

What constitutes effective performance-based assessment?

- Process of development is key
  - Working with all stakeholders to gain consensus
    - Faculty, instructors, teaching assistants, students
  - What characteristics are important?
    - Relevance
  - How much variability is typical?
    - Appropriate scaling

What constitutes effective performance-based assessment?

- Task selection must be strategic
  - Competency-oriented vs. benchmark-oriented
    - Important for longitudinal use

- Construct with raters in mind
  - Even number of rating categories
    - Avoid "split the difference" phenomena
  - Include 0
    - Differentiate between "absent" and "poor" performance

What constitutes effective performance-based assessment?

- Train your raters
  - Attain and maintain inter-rater and intra-rater reliability as much as possible
  - Use varied exemplars
    - High, medium, and low quality
- Use clear, concrete, and observable standards for each level and criterion
  - Bloom's revised taxonomy

Rubric example
Universal Lab Rubric (part 1)

Criteria	0 Not addressed	1 Novice	2 Intermediate	3 Expert
Methods: Experimental design				
Experimental design is likely to produce salient and fruitful results (tests the hypotheses posed).	Methods are: • Inappropriate • Poorly explained or indecipherable	Methods are: • Appropriate • Clearly explained • Drawn directly from coursework • Not modified where appropriate	Methods are: • Appropriate • Clearly explained • Modified from coursework in appropriate places, or • Drawn directly from a novel source	Methods are: • Appropriate • Clearly explained • A synthesis of multiple previous approaches or an entirely new approach

Rubric example
Universal Lab Rubric (part 1)

Criteria	0 Not addressed	1 Novice	2 Intermediate	3 Expert
Discussion: Conclusions based on data selected				
Conclusion is clearly and logically drawn from data provided. A logical chain of reasoning from hypothesis to data to conclusions is clearly and persuasively explained.	• Conclusions have little or no basis in data provided. • Connections between hypothesis, data, and conclusion are non-existent, limited, vague, or other insufficient to allow reasonable evaluation of merit	• Conclusions have some direct basis in the data, but may contain some gaps in logic or data or are overly broad. • Connections between hypothesis, data, and conclusions are present but weak	• Conclusions are clearly and logically drawn from and bounded by the data provided with no gaps in logic. • Reasonable and clear chain of logic from hypothesis to data to conclusion is made.	• Conclusions are completely justified by data. • Connections between hypothesis, data, and conclusions are comprehensive and persuasive. • Synthesis of data in conclusion may generate new insights.

Activity

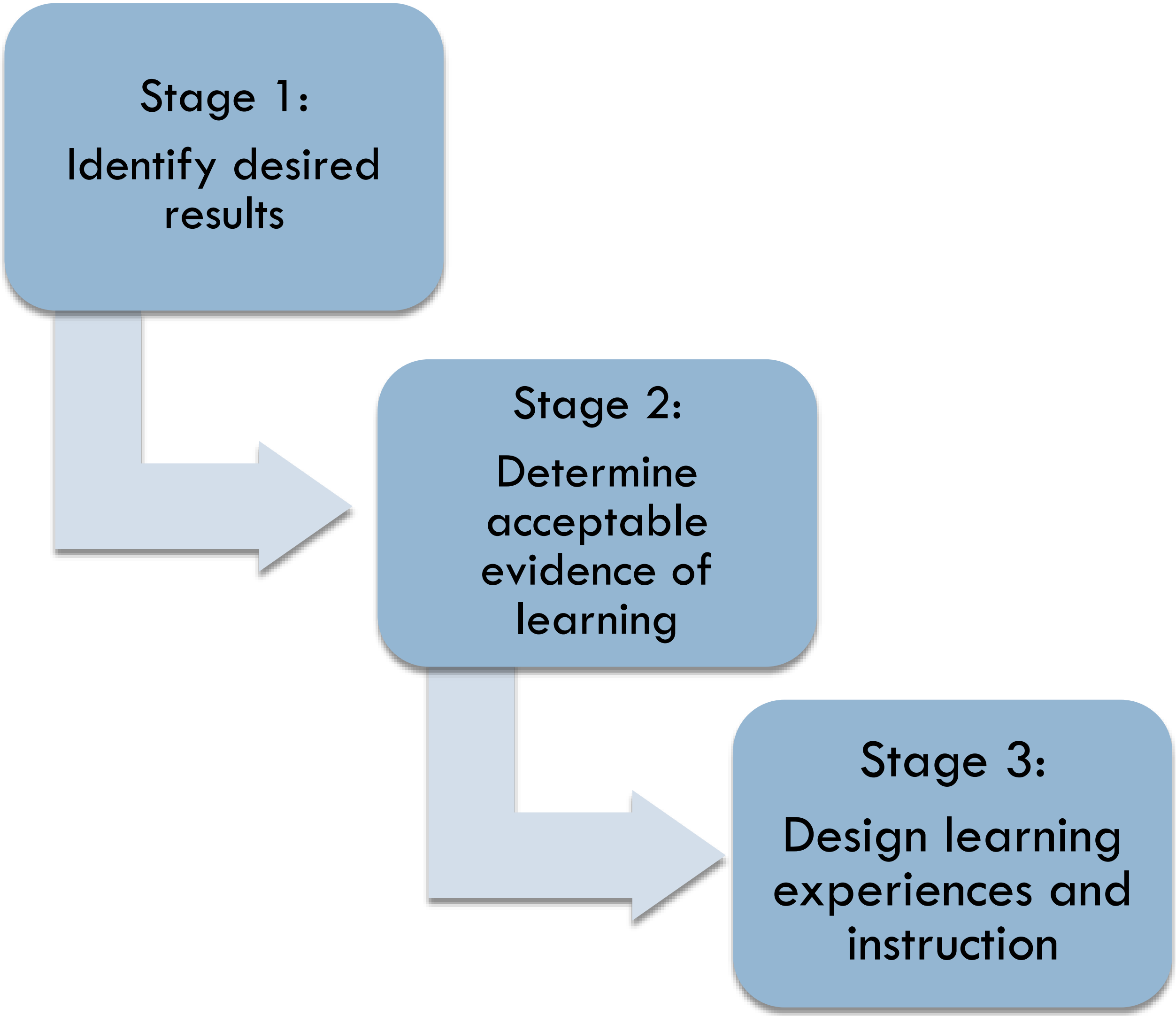
- Select 1 learning objective that you developed earlier this morning
- Create an assessment rubric for that learning objective

←——— **EVALUATION LEVELS** ———→

CRITERIA	0	1	2	3

DEVELOPING A SYLLABUS WITH BACKWARD DESIGN

Developing a syllabus with backward design



Developing a syllabus with backward design

Stage 1:

Identify desired results

- Focus on your learning goals and objectives
- These should be “big” ideas, concepts you want your students to understand enduringly

Developing a syllabus with backward design

Stage 2:

Determine acceptable evidence of learning

- Determine how students will demonstrate their knowledge, learning
- Focus on the assessment before designing the learning activities

Developing a syllabus with backward design

Stage 3:

Design learning experiences and instruction

- Plan instructional activities
- Build in collaboration
- Remember tenets of instructional design
  (see next slide)

Syllabus construction:
Tenets of instructional design

- Present new information in order from the simplest to the most complex
- Do not present unnecessary information
- Provide many opportunities for practice
- Eliminate/reduce unnecessary distractions
- Maintain a low-threat environment
- When learners revert to old habits, supportively redirect attention to task
- Limited quantity of information that any individual is responsible for processing at one time

Backward design:
An example from mathematics

Stage 1: Identify desired results

- What do numbers represent?
- How can numbers represent real-world phenomena?
- What do effective problem solvers do when they get stuck?

Stage 2: Determine acceptable evidence of learning

- Can explain concepts, principles, and processes
- Can interpret data
- Can apply concepts to new complex contexts

Stage 3: Design learning experiences and instruction

- Teach a concept to someone else
- Make sense of data through analogies, models, or stories
- Incorporate new learning into an applied, cumulative project

Backward design:
An example from engineering design

Stage 1:
Identify desired results

- Communicate well using design principles
- Sketch or CAD objects effectively
- Work collaboratively in teams

Stage 2:
Determine acceptable evidence of learning

- Generate and interpret technical drawings, charts, images
- Constructive participation in a team activity

Stage 3:
Design learning experiences and instruction

- Sketch multiple views of 3D objects
- Give oral presentations using drawings, images
- Require group activity using sketches

Examples of backward designed syllabi (in your handouts)

- Engineering:
  - Introduction to Engineering
  - Introduction to Environmental Engineering
  - Human Machine Systems

- Sciences:
  - Genetics and Molecular Biology
  - Mechanical Physics
  - Observational Astronomy
  - Quantum Mechanics

Activity

- FIRST: Reflect on the learning objectives for your class that you wrote yesterday
  - Are they "big picture" enough?
  - Are they realistic and assessable?
- SECOND: Determine what you believe would be acceptable evidence that your students met those objectives
- THIRD: Create assignments, tasks, and activities that will provide you the evidence that your students met the objectives?
  - Looking for inspiration? Remember the learner-centered pedagogies!

Homework

- Think of problems you face with your own teaching, and questions you would like to ask us about those problems.

- Write down those questions on index cards to share with the workshop presenters tomorrow morning.

REVIEW AND OVERVIEW DAY 3

- Developing learning objectives for your course
- Assessing students' learning
  - Developing effective rubrics
- Developing a syllabus with backward design