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

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October 14-17, 2013
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)

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

   - Integrate different ideas
   - Improve practice
   - 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

Learning How to Learn
- Self-directed learning

Foundational Knowledge
- Understanding
- Remembering

Caring
Developing new:
- Feelings
- Interests
- Values

Application
- Skills
- Thinking
- Managing projects

Human Dimension
Learning about:
- Oneself
- Others

Integration
Connecting:
- Ideas
- People
- Realms of life

©2003 L. Dee Fink, Creating Significant Learning Experiences
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
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

- **Knowledge**: To know specific facts, terms, concepts, principles, or theories
- **Comprehension**: To understand, interpret, compare, contrast, or explain
- **Application**: To apply knowledge to new situations, to solve problems
- **Analysis**: To identify the organization structure; to pull meaning from parts, relations, and organizing principles
- **Evaluation**: To judge the quality of something based on its adequacy, value, logic, or use
- **Synthesis**: To create something, to integrate ideas into a solution, to propose an action plan, to formulate a new classification scheme

Krathwohl, 2002
## Bloom’s revised taxonomy action verbs

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

[Bar chart showing the comparison between accurate and inaccurate perceptions of performance among faculty and students in fall and spring.]
DEVELOPING EFFECTIVE RUBRICS
Constructing an evaluation rubric

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Constructing an evaluation rubric

<table>
<thead>
<tr>
<th>CRITERIA</th>
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<tbody>
<tr>
<td>Hypotheses have scientific merit</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Experimental design is likely to produce salient and fruitful results (tests the hypotheses posed).</td>
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</table>
Constructing an evaluation rubric

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>Evaluation Levels</th>
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<tbody>
<tr>
<td></td>
<td>0 Unsatisfactory</td>
</tr>
<tr>
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Examples of evaluation levels

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
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</thead>
<tbody>
<tr>
<td>Novice</td>
<td>Apprentice</td>
<td>Proficient</td>
<td>Expert</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>Needs improvement</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>Satisfactory</td>
<td>Commendable</td>
<td>Exemplary</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>Developing</td>
<td>Proficient</td>
<td>Accomplished</td>
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</tbody>
</table>
## Constructing an evaluation rubric

### EVALUATION LEVELS

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

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</table>
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
## Methods: Experimental design

Experimental design is likely to produce salient and fruitful results (tests the hypotheses posed).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>0 Not addressed</th>
<th>1 Novice</th>
<th>2 Intermediate</th>
<th>3 Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methods are:</td>
<td>Inappropriate</td>
<td>Appropriate</td>
<td>Appropriate</td>
<td>Appropriate</td>
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<tr>
<td></td>
<td>Poorly explained or indecipherable</td>
<td>Clearly explained</td>
<td>Clearly explained</td>
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<td></td>
<td>Drawn directly from coursework</td>
<td>Not modified where appropriate</td>
<td>Modified from coursework in appropriate places, or</td>
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<tr>
<td></td>
<td>Not modified where appropriate</td>
<td>Drawn directly from a novel source</td>
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<tr>
<td></td>
<td>Drawn directly from a novel source</td>
<td></td>
<td>A synthesis of multiple previous approaches or an entirely new approach</td>
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</tr>
<tr>
<td>Criteria</td>
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<td>2 Intermediate</td>
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<tr>
<td><strong>Discussion: Conclusions based on data selected</strong></td>
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<tr>
<td>Conclusion is clearly and logically drawn from data provided.</td>
<td>• Conclusions have little or no basis in data provided.</td>
<td>• Conclusions have some direct basis in the data, but may contain some gaps in logic or data or are overly broad.</td>
<td>• Conclusions are clearly and logically drawn from and bounded by the data provided with no gaps in logic.</td>
<td>• Conclusions are completely justified by data.</td>
</tr>
<tr>
<td>A logical chain of reasoning from hypothesis to data to conclusions is clearly and persuasively explained.</td>
<td>• Connections between hypothesis, data, and conclusion are non-existent, limited, vague, or other insufficient to allow reasonable evaluation of merit</td>
<td>• Connections between hypothesis, data, and conclusions are present but weak.</td>
<td>• Reasonable and clear chain of logic from hypothesis to data to conclusion is made.</td>
<td>• Connections between hypothesis, data, and conclusions are comprehensive and persuasive.</td>
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</table>
Activity

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

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<th>CRITERIA</th>
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DEVELOPING A SYLLABUS WITH BACKWARD DESIGN
Developing a syllabus with backward design

Stage 1: Identify desired results

Stage 2: Determine acceptable evidence of learning

Stage 3: Design learning experiences and instruction
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