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

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Summary of workshop agenda

Monday, 14 October
- Introductions
- Current Cambodian context for STEM education
- Strategies to promote awareness & encouragement of STEM fields, especially for girls
- Major trends in college teaching in U.S.

Tuesday, 15 October
- Debunking myths about learning
- Instructional design
- Encouraging innovation in STEM
Summary of workshop agenda

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

- Thursday, 17 October
  - Utilizing learner-centered approaches
  - Problems with implementation and overcoming barriers
  - Question and answer session
  - Conclusion
Introductions

- Please introduce yourselves to the others at your table.

- Then, nominate one person who will summarize:
  - Names of universities represented
  - Range of academic disciplines represented
  - Variety of university roles you currently perform
Discussion

- What has been your experience teaching STEM courses in Cambodian universities?

- What are some of the challenges you face in teaching STEM courses?

- What do you feel you will need to be prepared for an increase in STEM enrollment?
Faculty Preparation and Resources

- Challenges
  - Low capacity
  - Lack of materials and resources
  - Making courses interesting

- Needs
  - International faculty exchange programs/train lecturers overseas
  - Deeper lecturer knowledge
  - Better teaching methods
  - More laboratories and digital resources
  - Teaching assistants/human resources
Student Motivation

- Challenges
  - Limited background in subject
  - Limited English language skills
  - Students do not understand importance of subject
  - Students not committed to learning
  - Low self-esteem of students
  - Topics are challenging

- Needs
  - Encouragement to study science
  - Curriculum aligned with current jobs
  - Explanation of usefulness of science
Context

- Challenges
  - Younger lecturers, older students
  - Course evaluation structure
  - Communicating real life applicability
  - Lack of job opportunities

- Needs
  - Better student recruitment
  - Curriculum aligned with current jobs
  - More job opportunities
CURRENT CAMBODIAN CONTEXT FOR STEM EDUCATION
Primary objectives for today’s session

✓ To form a solid background of the current Cambodian educational context, and the important role that STEM education plays in the future of Cambodian economic development

✓ To become aware of strategies to promote awareness and encouragement of STEM fields to students, particularly girls, prior to college

✓ To understand the major trends in college teaching in the United States, including four learner-centered techniques
STRATEGIES TO PROMOTE AWARENESS AND ENCOURAGEMENT OF STEM FIELDS AMONG STUDENTS PRIOR TO COLLEGE

Especially for girls and women
Persistent dilemma regarding girls and STEM subjects in the U.S.

- Girls enroll in similar math and science courses in high school as boys, except for Physics and Calculus\(^1\)

- Girls generally do as well as boys on homework assignments and course grades in math and science\(^2\)

- However, girls have lower self-confidence in their math and science abilities, and show less interest in math or science-related careers\(^3\)

\(^{1}\) 2005 National Assessment of Educational Progress; \(^{2}\) 2006 College Board; \(^{3}\) Herbert & Stipek (2005); Jacobs et al. (2002)
Research-based Recommendations to Encourage Students in STEM

1. Teach students that academic abilities are expandable and improvable

   ✓ Teach that working hard to learn new things leads to improved performance

   ✓ Remind that the mind grown stronger over time, and understanding difficult material gets easier

2. **Provide prescriptive, informational feedback**

- Give feedback that focuses on strategies for learning instead of simply “right” or “wrong”
- Provide specific, positive feedback on effort expended working on a difficult problem
- Offer multiple opportunities for feedback on their performance, not just the final exam
3. Create a classroom environment that sparks curiosity and fosters long-term interest in math and science

- Embed math word problems and science activities in ways that are authentic to both girls and boys
- Capitalize on novelty to spark initial interest (i.e., change the teaching method or vary the assignment)
- Encourage girls and boys to examine their beliefs about what are typically male-oriented and female-oriented jobs
Research-based Recommendations to Encourage **GIRLS** in STEM

4. Expose girls to female role models who have succeeded in STEM
   - Invite older girls successful in math and science to mentor or tutor younger girls
   - Assign biographies about famous women scientists, engineers, and mathematicians
   - Mention the prevalence of women pursuing careers in STEM careers
   - Encourage parents to actively support their girls’ interests in STEM-related careers
Discussion

- Based on the last four slides, what can you be doing in your teaching and your classrooms to encourage your students to continue to study in a STEM field?
  - Teach students that academic abilities are expandable and improvable
  - Provide prescriptive, informational feedback
  - Create a classroom environment that sparks curiosity and fosters long-term interest in math and science
  - Expose girls to female role models who have succeeded in STEM

- Anything specific you can be doing to encourage the young women in your classes?
MAJOR TRENDS IN COLLEGE TEACHING IN THE UNITED STATES
Question:

- Close your eyes and imagine what a typical college classroom looks like.
  - What is the professor doing?
  - What are the students doing?
Teacher-centered versus Learner-centered

- **Teacher-centered**
  - An educational institution exists to provide instruction

- **Learner-centered**
  - An educational institution exists to promote learning

# Teaching-centered versus Learning-centered instruction

<table>
<thead>
<tr>
<th>Concept</th>
<th>Teacher-Centered</th>
<th>Learner-Centered</th>
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</thead>
<tbody>
<tr>
<td><strong>Teaching goals</strong></td>
<td>• Cover the discipline</td>
<td>Students learn:</td>
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<tr>
<td></td>
<td></td>
<td>• How to use the discipline</td>
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<tr>
<td></td>
<td></td>
<td>• How to integrate disciplines to solve complex problems</td>
</tr>
<tr>
<td><strong>Course structure</strong></td>
<td>• Faculty cover topics</td>
<td>• Students master learning objectives</td>
</tr>
<tr>
<td><strong>How students learn</strong></td>
<td>• Listening  &lt;br&gt; • Reading  &lt;br&gt; • Taking and passing exams</td>
<td>• Students construct knowledge</td>
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<tr>
<td></td>
<td></td>
<td>• Integrate new learning into old</td>
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<td></td>
<td></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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[http://assessment.uconn.edu/docs/TeacherCenteredVsLearnerCenteredParadigms.pdf](http://assessment.uconn.edu/docs/TeacherCenteredVsLearnerCenteredParadigms.pdf)
Discussion

- Which approach do you primarily use: teacher-centered or learner-centered?

- How do you think your students would react to a learner-centered approach?

- What skills would you need to acquire in order to use a learner-centered teaching approach?
Early tenets of learner-centered instruction: Active learning

- **Active Learning**: “Any instructional method that engages students in the learning process”
  - Students must do meaningful learning activities
  - Students must think about what they’re doing

- Instructors must “Guide” not “Tell”

Early tenets of learner-centered instruction: Learning styles

- **Learning styles**: different people learn in different ways
  - Implications: Teachers should adapt lessons to different styles of learning
  - Note: Contemporary data does not support this theory (more on this tomorrow)

Examples of learner-centered pedagogical techniques

- **THINK – PAIR – SHARE:**
  - Announce a discussion topic or problem to solve
  - Give students a few minutes to think of their own answer individually
  - Ask them to turn to their neighbor and discuss the topic or solution
  - Randomly ask some of the pairs to share their ideas with the class
Examples of learner-centered pedagogical techniques

- **PROBLEM-BASED LEARNING:**
  - Students explore real-world, hands-on problems and challenges
  - Students work in small groups
  - Instructors serve as guides and facilitators
Examples of learner-centered pedagogical techniques

- **CLICKERS:**
  - Teachers have students vote on answers using hand held electronic devices
  - Results are shown instantly, showing the instructor the percentage who understand the concept
  - Can be done without the technology
Examples of learner-centered pedagogical techniques

- **LEARNER CLASSROOM ASSESSMENTS:**
  - **1 Minute Papers:**
    - Students are given open-ended questions and 1 minute to respond (e.g. “What was the most important concept you learned today?” or “What still remains unclear?”)
  - **Just In Time Teaching:**
    - Students respond to a question, and the teacher reviews responses and adjusts the lesson “just in time” before next lesson
Richard Hake (1998)

- Studied 6,542 physics students in traditional courses and learner centered courses
  - Traditional Courses had .23 average normalized gain (g)
  - Learner Centered Courses had a .48 (g) gain in learning

- Found learner engagement strategies enhanced problem solving abilities, and increase mechanics-course effectiveness beyond traditional methods
Research on the benefits of learner-centered instruction

- Prince (2004)
  - Performed review of active learning techniques used in engineering classes
  - Although uneven results, found support for all forms of active learning involved
  - Found
    - Support for collaborative and cooperative learning over individual work and competition to promote achievement
    - Problem based learning may not improve test scores but likely to positively influence student attitudes, study habits, retain information longer, improve critical thinking skills, and problem solving skills when coupled with explicit instruction in these skills
Research on the benefits of learner-centered instruction

  - Reviewed evidence of student-centered active learning approaches
  - Found:
    - Learning involves the active construction of meaning by the learner
    - Individuals are likely to learn more when they learn with others than when they learn alone
    - Meaningful learning is facilitated by articulating explanations
Activity: Using the techniques

- Please move to tables with others of the same discipline

- Work as a table for 10 minutes to create one example of a classroom activity in your discipline you could use that incorporates either:
  - Think-pair-share
  - Problem-based learning
  - Clickers
  - Learner classroom assessments

- Write your activity on an index card and submit to facilitators
1. **Think-pair-share:**

Ask students to estimate metric tons of garbage polluted per day, first alone, then compare answer with partner, then one group shares with class.
1. Problem-based learning

Ask students to develop a cost-efficient biodegradable, non-toxic type of bag over the course of several weeks.
1. Clickers

Ask students to calculate the percent of toxic waste found in animals at the top of the food chain and then “click” in their answers via a multiple choice question.
1. Learner assessments

At the end of class, ask students to quickly write on paper the most important aspect you discussed in class today and see if their responses match up with what you had planned.
Activity: Using the techniques

- Please move to tables with others of the same discipline

- Work as a table for 10 minutes to create one example of a classroom activity in your discipline you could use that incorporates either:
  - Think-pair-share
  - Problem-based learning
  - Clickers
  - Learner classroom assessments

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Current Cambodian context

Strategies to promote awareness and encouragement of STEM fields to students prior to college

Major trends in college teaching in the United States