TOOLS FOR ASSESSING AND EVALUATING THE EFFECTIVENESS OF STEM INSTRUCTIONAL PRACTICES

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Overview

- To examine tools for assessing and evaluating the effectiveness of STEM instructional practices that are:
  - Developed locally or externally
  - Direct and indirect measures of effectiveness
  - Used to collect data or information from multiple sources/populations

- To examine faculty and instructional characteristics that lead to improved student engagement and learning.
To have a positive effect on instructional practice, faculty should possess the following:

- **Knowledge and understanding**
  - Of subject matter and teaching

- **Skills and competencies**
  - Effective communication
  - Good organization of subject matter and course
  - Flexibility in approaches to teaching
  - Fairness in assessment and grading

- **Attitudes and dispositions**
  - Positive attitude toward students
Instructional Practices and Student Engagement and Learning

- Instructional practices have an effect on students’ engagement and learning in at least three ways - their:
  - Knowledge and understanding
  - Skills and competencies
  - Attitudes and dispositions
Improving Student Learning in STEM

Focus on Faculty

- Improving Teaching and Learning (by individual faculty)
  - At the classroom level

- Improving Learning Productivity (by scaling up; large scale)
  - At the program level
  - At the institutional level
  - At the national level
Effective STEM Instructional Practices

Do we need more evidence about the effectiveness of active and collaborative teaching strategies and related efforts to foster student engagement in their own learning?

“The answer is a definitive no. The general literature on college teaching and learning as summarized by many authors, Pascarella & Terenzini (2005) and Kuh et al. (2005) prominently among them, provides clear research evidence that active and collaborative instructional strategies are more effective than traditional lecture and discussion across most if not all dimensions of student learning” (Fairweather, 2008).

- Believe in your students
- Adopt a student-centered focus
- Foster curiosity
- Provide hands-on experiential learning
- Increase collaboration among students
- Be an inspiring leader and role model for students
- Grow as a learner
- Participate in communities of practice and research
- Be flexible
- Recognize, but strive to overcome your limitations as well as those of the environments in which teaching and learning takes place
Tools for Assessing and Evaluating STEM Instructional Practices

- **Believe in your students**
  - Course evaluations
  - Student focus groups

- **Adopt a student-centered focus**
  - Content analysis of syllabi w/ student learning outcomes

- **Foster curiosity**
  - Peer observations of teaching
  - Use of open-ended questions

- **Increase collaboration among students**
  - Observations
  - Teamwork skills among students

- **Provide hands-on experiential learning**
  - Course evaluations
  - Chair & Peer observations of teaching
  - Rubric for assessing amount of passive vs. active learning activities
  - Analysis of types of course embedded assessments
Tools for Assessing and Evaluating STEM Instructional Practices (cont’d)

- Be an inspiring leader and role model for students
  - Peer evaluations of research and service

- Grow as a learner
  - Certificates of participation in PD over time

- Participate in communities of practice and research
  - Active membership in professional organizations
  - Research record

- Be flexible
  - Course evaluations
  - Peer evaluations

- Recognize, but strive to overcome your limitations as well as those of the environments in which teaching and learning takes place
  - Self-evaluations
  - Assessment and evaluation of material, financial and human resources
An Example: Course Evaluations

- Course evaluations are designed to measure various aspects of “course” and “instructional” effectiveness.
- At least three criteria are used to select items that appear on course evaluation instruments:
  - Items that experts believe are most important to teaching and that have appeared in the research literature.
  - Items that reflect areas of instruction that students are capable of observing and judging.
  - Items that faculty members believe are most useful for instructional improvement.

Excerpted from The Development of the Student Instructional Report II by John A. Centra.
Dimensions of Instructional Practice

Student Instructional Report (SIR) II

- Course Organization and Planning
- Communication
- Faculty/Student Interaction
- Assignments, Exams and Grading
- Course Difficulty, Workload and Pace
- Methods of Instruction*
- Student Effort and Involvement
- Course Outcomes

IDEA Center

- Course Organization and Planning
- Clarity, Communication Skills
- Teacher-Student Interaction, Rapport
- Course Difficulty, Workload
- Grading and Examinations
- Student Self-rated Learning
Methods of (Active) Instruction

Student Instructional Report (SIR) II

Compared to most other courses, how much more or less did you engage in the following:

- Problems or questions for small group discussions
- Term paper(s) or Project(s)
- Laboratory exercises
- Assigned group projects
- Case studies, simulations, or role playing
- Course Journals
- Computers as aids in instruction

Scale: 1=“Much less than …” to 5=“Much more than…”

IDEA Center

Describe the frequency of your instructor’s teaching procedures:

- “Formed teams for discussion groups to facilitate learning”
- “Encouraged students to use multiple resources”
- “Involved students in “hand-on” projects such as research, case studies, or real life”
- “Asked students to share ideas and experiences with others whose backgrounds and interests are different from their own”
- “Gave projects, tests, or assignments that required original or creative thinking”

Scale: 1=“Hardly Ever to 5=“Almost Always”
## Tools for Assessing & Evaluating STEM Student Learning

<table>
<thead>
<tr>
<th>Internal</th>
<th>External</th>
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<tbody>
<tr>
<td>Faculty-developed assignments, tests and examinations</td>
<td>National standardized tests and assessments (ETS Subject Tests, etc).</td>
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<tr>
<td>Locally-developed surveys and questionnaires</td>
<td>National instruments that can provide comparative data (FSSE, NSSE, CIRP, etc).</td>
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<tr>
<td>Locally-developed rubrics</td>
<td>VALUE (Valid Assessment of Learning in Undergraduate Education) rubrics developed by AAC&amp;U</td>
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<td>Interviews and focus groups</td>
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“The ETS Major Field Tests are comprehensive undergraduate and MBA outcomes assessments designed to measure the critical knowledge and understanding obtained by students in a major field of study. The Major Field Tests go beyond the measurement of factual knowledge by helping you evaluate students’ ability to analyze and solve problems, understand relationships and interpret material from their major field of study.”
The ETS Major Field Tests in STEM

- Biology
- Chemistry
- Computer Science
- Mathematics
- Physics
Examples of Biology Items

**Biology**

Compared to a eutrophic lake, an oligotrophic lake tends to have a greater:

- (A) supply of oxygen in the deep waters
- (B) number of blue-green algae
- (C) biological oxygen demand
- (D) amount of hydrogen sulfide
- (E) amount of degradable organic matter

**Biology**

The evolutionary process most likely to account for the fixation of neutral or even nonadaptive alleles or allele combinations in small populations is called:

- (A) recombination
- (B) Lamarckian selection
- (C) Darwinian selection
- (D) Genetic drift
- (E) Mutation
An Example: National Survey of Student Engagement (NSSE) Results

“The purpose of NSSE is to assess the extent to which students participate in empirically derived effective educational practice, called High Impact Practices (i.e., “hips”) and to estimate what students gain from their college experience.”
High Impact Educational Practices

- First-Year Experiences
- Common Intellectual Experiences
- Learning Communities
- Writing Intensive Courses
- Collaborative Assignments and Projects
- Undergraduate Research
- Diversity/Global Learning
- Service or Community-Based Learning
- Internships
- Capstone Projects

Source: Kuh (2008)
Collaborative Assignments and Projects

- Collaborative learning combines three key goals:
  - Learning to work and solve problems with others.
  - Strengthening one’s own understanding by listening seriously to the insights of others, especially those with different backgrounds and life experiences.
  - Learning to respect different perspectives and worldviews.
Five NSSE Benchmark Indicators

- Level of Academic Challenge (LAC)
- Active and Collaborative Learning (ACL)
- Student-Faculty Interaction (SFI)
- Enriching Educational Experiences (EEE)
- Supportive Campus Environment (SCE)
Active and Collaborative Learning (ACL)

- To what extent are students asked to think about and solve problems in different settings, collaboratively with others.

- How often do students:
  - Make presentations in class
  - Work with classmates inside and outside of class
  - Participate in a community-based projects as part of the course
  - Tutor or teach other students
Reliability and Validity of Assessment and Evaluation Results

- **Reliability**
  - Refers to the consistency of assessment results.

- **Validity**
  - Refers to the appropriateness of the inferences and uses made from assessment results.
Validity Approaches

- Conduct alignment studies to determine the overlap between instructional goals and objectives and the constructs/items on the assessment and evaluation tools.
- Correlate student ratings with achievement.
- Correlate student ratings with other criteria: instructor self-ratings; ratings by administrators, peers, alumni, or trained observers; student comments.
- Examine possible sources of bias.

Question and Discussion

What will you do to increase the use of effective instructional practices in STEM, and thereby improve student engagement and learning for all students?
Faculty who participate in professional development seem to be committed to improving their instructional practices. Furthermore, most are using effective pedagogies (e.g. active and collaborative instructional methods).

The greatest gains in STEM learning productivity will come from finding ways to engage a large group of STEM in any form of pedagogy that increases student engagement. These strategies will depend more on enhancing the value of teaching in faculty rewards (Fairweather, 2005).
Role of Research Evidence in STEM Instructional Effectiveness

- Research evidence is a necessary, but not a sufficient condition for large scale adoption of effective instructional practices.

- Other factors include faculty work load, faculty rewards, leadership, and resources (Fairweather, 1996; Fisher, Fairweather, & Amey, 2003).
References