EVIDENCE-BASED STEM INSTRUCTIONAL PRACTICES THAT ARE MOST EFFECTIVE IN SPECIFIC STEM DISCIPLINES

Gerunda B. Hughes, Professor and Director
Office of Institutional Assessment and Evaluation
Howard University
QEM Consultant
Overview and Purpose

**Overview:** To explore an array of research-based teaching and learning experiences for STEM majors (and others) in specific disciplines that will:

- more deeply engage them in the subject matter;
- help them to learn the content more securely;
- inspire them to persist in their STEM majors; and
- strengthen their resolve to pursue a career in a STEM field.

**Purpose:** To examine the role of engagement, high impact practices, and problem-based learning in STEM education.
At the most fundamental level, students must be engaged in the learning process, if learning is to be optimized (Boykin & Noguera, 2011).

This kind of engagement is not simply time on task or attending to a lesson.

A growing amount of research provides evidence that focused engagement is linked to favorable outcomes for minority students, especially those who have been placed at risk for academic failure (Borman & Overman, 2004; Tucker et al., 2002, Wenglinsky, 2004).
Classroom-based Engagement

- **Behavioral engagement** entails effort and persistence along with paying attention, asking pointed questions, seeking help that enables one to accomplish the task at hand, and participating in class discussion.

- **Cognitive engagement** connotes investment aimed at acquiring critical and higher-order thinking skills, comprehending complex concepts and issues, and solving challenging problems.

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
- Estimate what students gain from their college experience (i.e., benchmark comparisons)

- Over 700 colleges and universities in the United States participate in NSSE.
- NSSE results are used to improve the educational experiences of undergraduate students.
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)
First-Year Experiences

- First-year seminars and other programs introduce students to the culture of the university, school or college, department or program.

- High-quality first-year experiences convey what is valued and what is expected.
Common Intellectual Experiences

- A set of experiences centered on broad integrative themes, with an emphasis on student learning outcomes, with curricular and co-curricular options available to students.
Learning Communities

- The key goals of learning communities are to:
  - encourage integration of learning across courses, and
  - involve students with “big” questions that matter beyond the classroom.
- Many learning communities explore common topics and/or common readings through the lenses of different disciplines.
These courses emphasize writing at all levels of instruction and across the curriculum.

Students are encouraged to produce and revise various forms of writing for different audiences in different disciplines.

This repeated practice in writing “across the curriculum” also leads to enhanced learning in critical thinking and other desired outcomes.
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.
The goal of undergraduate research is to involve students in empirical, systematic investigation, cutting-edge technologies, and the sense of excitement that comes from working to answer important questions.

How is this accomplished? Through faculty-led or student-led research projects.
The goal of undergraduate research is to involve students in empirical, systematic investigation, cutting-edge technologies, and the sense of excitement that comes from working to answer important questions.

How is this accomplished? Through faculty-led or student-led research projects.
Diversity/Global Learning

- These programs help students explore cultures, life experiences, and worldviews different from their own.

- Areas of focus may include racial, ethnic, and gender inequality, or continuing struggles nationally and internationally for human rights, freedom or power.
This is field-based, “experiential learning” with community partners which allows students to both apply what they are learning in real-world settings and reflect in a classroom setting on their service experiences.

Students learn to analyze and solve problems and develop skills for work and life.
Internships

- This form of experiential learning provides students with direct access to a work setting—usually related to their career interests—and gives them the benefit of supervision, coaching, and mentorship from professionals in the field.
Capstone Courses and Projects

- These culminating experiences require students who are near the end of a “transition point” to create a project thatintegrates and applies what they have learned.

- The transition may be a change in classification (e.g., rising sophomore) or the completion of a course of study (e.g., general education, program completion or graduation).

- The project might be a research paper, a performance, a portfolio of “best works”, evidence of improvement over time, or an exhibit of artwork.
Why are HIPs Effective?

- HIPs typically demand that students devote considerable time and effort to purposeful tasks.

- HIPs put students in circumstances that essentially demand they interact with faculty, peers, or other significant educational professionals about substantive issues.

- While engaging in HIPs, students are more likely to receive feedback about their progress and performance.
Why are HIPs Effective?

- HIP experiences often challenge students to develop new ways of thinking about and responding to novel circumstances as they work with peers and others, inside and outside of the classroom, on and off campus.

- HIPs provide students with an opportunity to integrate, synthesize, and apply knowledge to deep and purposeful experiences.
To what extent are a select number of HBCUs engaging their students in meaningful learning, and how do their results compare to other types of institutions?
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)
## Comparison Institutions

<table>
<thead>
<tr>
<th>Peer/Aspirants</th>
<th>HBCUs</th>
</tr>
</thead>
<tbody>
<tr>
<td>American</td>
<td>Dillard</td>
</tr>
<tr>
<td>Case Western Reserve</td>
<td>Fisk</td>
</tr>
<tr>
<td>Emory</td>
<td>Grambling</td>
</tr>
<tr>
<td>Polytechnic Institute of New York University</td>
<td>Morgan</td>
</tr>
<tr>
<td>UMBC</td>
<td>Norfolk State</td>
</tr>
<tr>
<td>University of Miami</td>
<td>Tennessee State</td>
</tr>
<tr>
<td></td>
<td>UMD-ES</td>
</tr>
</tbody>
</table>
Student-Faculty Interactions

- To what extent do students interact with faculty members inside and outside of the classroom?

- How often do students:
  - Discuss ideas from readings with faculty outside of class?
  - Receive prompt written or oral feedback from faculty on their academic performance?
  - Work on research project with faculty outside of course requirements?
Project-Based Learning (PBL)

- Project-Based Learning a systematic teaching method that engages students in learning essential knowledge and life-enhancing skills through an extended, student-influenced inquiry process structured around complex, authentic questions and carefully designed products and tasks.

Taken from: http://pbl-online.org/About/whatisPBL.htm
Effective Professional Development focuses on:

- **Core features of Professional Development** (Garet, Porter, Desimone, Birman, & Yoon, 2002)
  - Focus on Content
  - Promote Active Learning
  - Foster Coherence

- **Teacher Outcomes**
  - Knowledge and skills
  - Change in classroom teaching/assessment practices
    - Student achievement
Connecting HIPs, Engagement, and Problem-Based Learning: An Example

The Problem: What were the effects of migration or immigration on the health/well-being and the socio-economic status and growth of different racial/ethnic groups in the United States from the mid-18th to the mid-20th century?

- What role can each of the high impact practices (HIPs), 21st Century skills, and subject areas play in answering this question?
  - HIPs: Common intellectual experiences, Collaborative assignments and projects, Learning communities, and undergraduate research;
  - 21st Century Skills: Creativity and innovation, Critical thinking and problem solving, Communication and collaboration, information literacy, media literacy, and ICT (information, communication and technology) literacy, life and career skills; and
  - English, mathematics, geography, economics, medicine and allied health sciences, history, sociology, psychology, engineering, the arts, and …

http://www.p21.org/overview/skills-framework
Application: Transforming Past Lessons for 21\textsuperscript{st} Century STEM Learners

- Locate that special lesson – Either a required lesson or your favorite lesson. You may also expand it into a project with several lessons.

- State the student learning outcomes – This is a way to provide relevance to students and perhaps to collaborate with a colleague.

- Incorporate at least two 21\textsuperscript{st} century skills – Research indicates that the three easiest 21\textsuperscript{st} century skills to assess are (1) critical thinking/problem solving; (2) oral or written communication; and (3) collaboration.

- Outline the technology that is to be used – Remember that the successful use of technology may require some instruction. This instruction can be a workshop, on-line tutorials, peer tutoring, or handouts.

References


- Boylin, A.W., & Noguera, P. (2011). *Creating the opportunity to learn: Moving from research to practice to close the achievement gap.* Alexandria, VA: ASCD.


Include an advance organizer – An advance organizer helps student connect what they have already learned to their current assignment. It provides additional structure and meaning to students.

Provide continuous feedback through formative assessment – The role of formative assessment is to give quality to the final outcomes or product, support the standards, and enhance learning. Feedback can come from multiple sources: professor, peers, or self.

Describe the final product or outcome - It should reflect that standards and indicate how much time students will have to develop it.

Develop an assessment rubric – This is your summative assessment and should include criteria for assessing content and 21st century skills. Weight each criteria appropriately.

Discussion/Questions