EXAMPLES OF EVIDENCE-BASED STEM INSTRUCTIONAL PRACTICES

Workshop on Assessment and Evaluation of STEM Instructional Practices at TCUP-supported Institutions
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The context: Engage to Excel: K-12 Education in Science, Technology, Engineering and Math (STEM Education for America’s Future, The president’s Council of Advisors on Science and Technology, February 2012

- “Data show that evidence-based teaching methods are more effective in reaching all students—especially the “underrepresented majority” – the women and members of minority groups who now constitute approximately 70 percent of college students while being underrepresented among students who receive undergraduate STEM degrees (approximately 45%)”

- PCAST’s recommendations:
  - Catalyze widespread adoption of empirically validated teaching practices
  - Advocate and provide support for replacing student laboratory courses with discovery-based research courses
Evidence-based Instructional Strategies

- Evidence-based or research-based instructions provide teachers with tried-and-tested strategies to improve student learning
- Focus shifted from passive learning to:
  - Student-centered learning
  - Technology-enabled learning
Many Labels, Same Elements

- Flexible learning
  - Personalized and individualized; choice, convenience
- Experiential learning
  - Reflection on doing; direct experiences
- Self-directed learning
  - Responsible for decisions about own learning; work with others to achieve learning goals
Student-centered Learning (SCL)  
Main Principles

- The learner has full responsibility for her/his learning
- Involvement and participation are necessary for learning
- The relationship between learners is more equal, promoting growth, development
- The teacher becomes a facilitator and resource person
- The learner sees himself differently as a result of the learning experience

Collaborative Learning

- Refers to an instruction method in which students at various performance levels work together in small groups toward a common goal. The students are responsible for one another's learning as well as their own. Thus, the success of one student helps other students to be successful.

Cooperative Learning

- Refers to students working in teams on an assignment or project under conditions in which certain criteria are satisfied, including:
  - Positive interdependence
  - Individual accountability
  - Face-to-face promotive interaction
  - Appropriate use of collaborative skills
  - Group processing
- More structurally defined than collaborative learning

Inquiry-based Learning

- An approach to teaching and learning that places students’ questions, ideas, and observations at the center of the learning experience.
- Educators play an active role throughout the process by establishing a culture where ideas are respectfully challenged, tested, redefined and viewed as improvable, moving students from a position of wondering to a position of enacted understanding and further questioning (Scardamalia, 2002).

Under the Peer-led Team Learning (PLTL) model, undergraduate students who have done well in the class previously are recruited and trained as peer leaders who guide the efforts of a group of six to eight students. These peer-led groups meet weekly to work together on problems that are carefully structured to help the students build conceptual understanding and problem-solving skills.

Problem-based Learning (PBL)

- An instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a **defined problem**.

- The instructor identifies a problem that is purposely complex and vague yet intriguing enough to excite students to inquire about it, do research on it and draw reasonable multiple solutions or conclusions on the problem.

Process Oriented Guided Inquiry Labs (POGIL)

- In POGIL classrooms students work in small groups on specially designed activities designed to develop mastery of both course content and **key process skills** (information processing, problem solving, critical thinking, teamwork, communication, metacognition, and assessment).
- The guided inquiry materials is based on the learning cycle paradigm

Supplemental Instruction (SI)

- SI is a voluntary program that offers free, regularly scheduled study sessions for historically difficult courses (classes with a minimum 30% rate of students that drop, withdraw, or fail).
- SI sessions are facilitated by SI Leaders who are undergraduate students who have previously taken the course and demonstrated academic competency in the subject area.

University of Missouri-Kansas City. n.d. “Overview of Supplemental Instruction
Think-Aloud Pair Problem Solving (TAPPS)

- A means to encourage problem-solving skills by verbalizing to a listener one's problem-solving thoughts. Students are paired and given a series of problems. The two students are given specific roles that switch with each problem (Problem Solver and Listener). The problem solver reads the problem aloud and talks through the solution to the problem. The listener follows all of the problem solver's steps and catches any errors that occur.

Universal Design for Learning (UDL)

- Is a scientifically valid framework for guiding educational practices that:
  - Provides flexibility in the ways information is presented, in the ways that students respond or demonstrate knowledge or skills, and in the ways students are engaged; and
  - Reduces barriers to instruction, provides appropriate accommodations, supports, and challenges, and maintains high achievement expectations for all students, including students with disabilities and students who are limited English proficient.

Higher Education Opportunity Act, 2008
When Implementing UDL Guidelines In Your Class:

- Create an inclusive learning environment that takes into account all relevant dimensions of difference that you can expect to encounter among your students.
- Maximize the potential for all students to achieve by minimizing barriers to materials, learning activities, and methods of assessment.
Technology-enabled Learning

- The adoption of new technology is prevalent throughout all aspects of society
- Technology has changed the way we teach, communicate, conduct business, and interact socially. It has changed the way we live
- Technology permits migration of students’ solutions from the classroom to the digital village
- Funding agencies recognize the importance of STEM education and are funding proposals that introduce students to technology to improve education and to ensure that the US can compete in the global economy
Blended Learning

- A formal education program in which a student learns in part through online delivery of content and instruction with some element of student control over time, place, path and/or pace, and at least in part at a supervised brick-and-mortar location away from home.

Is a pedagogical model in which the typical lecture and homework elements of a course are reversed.

Short video lectures are viewed by students at home before the class session, while in-class time is devoted to exercises, projects, or discussions to reinforce their understanding of the material.

Distance Learning

- At its most basic level, distance education takes place when a teacher and student(s) are separated by physical distance, and technology (i.e., voice, video, data, and print) is used to bridge the instructional gap.
- Broad mix of technologies, methodologies, and media should be used for optimal outcome

Willis, B. (1993). Distance Education: A Practical Guide. University of Idaho
Technology Used in Education

- Computers in the classroom.
- Laptops, tablet PCs, notebook computers.
- Software for Self-Paced Learning
- Smart-boards, Interactive white boards, clickers, video clips, audio clips.
- Webinars and guest lectures from remote sites, lecture capture software.
- On-line testing software, on-line lecture software, on-line office hours, chat-rooms, discussion boards.
Emerging Technology in Education

- **Cloud Computing** – Students and educators can collaborate on-line using web-based tools. Schools can experience significant cost savings when using this technology. (i.e. using Google apps for email and document collaboration)

- **Mobile Technology** – Students and educators are seeing the increased potential of using these devices in education as they are less expensive than laptops and need less infrastructure to support. (i.e. 5-12th graders use smartphones and sightings to track GPS-tagged birds)

- **Personal Learning Environments** - This is not simply a technology, but rather a process or approach to teaching and learning that is individualized and different for each person. (i.e. students can add blogs and social media networks to enhance their personal learning environment.)
Factors Influencing Implementation of Various Strategies

- Institutional culture
- Class size
- Discipline
- Course level (maturity of students)
- Instructor preferences
- Nature of facilities
Problems with Using Technology

- Students may use computers to do other things like surf the Internet, chat with a friend, or read email.
- Multimedia is often thought of as being used for entertainment rather than for learning and instruction.
- Instructors avoid the use of technology because they do not understand how to use it effectively.
- Support is not always readily available when technical problems or questions arise.
General Challenges Implementing New Strategies

- Difficulty transition of teacher roles as knowledge provider to facilitator of learning
- Time consuming
- Costly
- May not be readily accessible
- How do we balance the cost with the benefits they provide? Are the gains worth the effort?
References

- President’s Council of Advisors on Science and Technology (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics.* Washington, DC: Executive Office of the President, President’s Council of Advisors on Science and Technology.
References