Assessment and Evaluation of Instructional Strategies Used in Mathematics and Computer Science

Quality Education for Minorities Network’s Workshop on Evidence-based STEM Instructional Strategies
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What are the instructional methods that mathematics and computer science professors use?

How do college mathematics and computer science professors measure the effectiveness of their instructional practices?
Instructional Practices

- **Traditional**—A teacher centered method that translates information—skills, facts, concepts—to students.

- **Cooperative**—Direct collaboration between educators to coordinate lessons for the classroom.

- **Collaborative**—Promoting learning through small group exercises, student led discussions, or joint projects, tests, and assignments.

- **Inquiry Based/Problem Based**—Encourages student exploration of academic content through investigation (posing and answering of questions).
Instructional Practices (Cont’d.)

- **Blended Instruction** – The integration of online instruction with traditional teaching methods

- **Competency Based** – Teaching to student needs at a pace set by the student

- **Reform-Oriented** – positive and significant impact on student achievement (National Council of Teachers of Mathematics, 2000)
  - A problem solving approach

  “That which focuses on a conceptual understanding of mathematics concepts that integrate and connect prior knowledge with new experiences through active inquiry-based teaching that is student centered.”  -(Jong, 2008)
Approaches to Teaching Inventory (ATI)  
(Trigwell & Prosser, 1999)

- Aim: Inventory to measure teacher beliefs, conceptions, and behaviors

- Two scales (11 items):
  - Information Transmission/Teacher-Focused Approach: “Sage-on the Stage” – emphasis on facts and skills
  - Conceptual Change/Student Focused Approach: “Facilitator of Understanding” - students construct their own understanding

- Two subscales: Intention items & Strategy items
Approaches to Teaching Inventory (ATI-Revised) (Finn, 2010)

- Conference Board of the Mathematics Sciences
  - American Mathematical Society & Mathematical Association of Mathematics (MAA)
  - N=4574 (31% ineligible); N=3156 eligible participants (56% respond rate)

- Adapted to include
  - open ended questions
  - questions that centered around NCTM and MAA standards
  - Classroom demographics
  - Professional Habits
ATI-R

Courses:
- College Algebra
- Quantitative Reasoning
- PreCalculus
- Calculus
- Geometry
- Abstract Algebra
- Discrete Math
- Analysis
- Differential Equations/Dynamical Systems
- Logic and Proof courses,
ATI-R Results

- Three dimensions of Instructional Strategies
  - Conceptual Change Student Focused - Professor asks students to do
  - Conceptual Change Teacher Focused - Professor does
  - Information Transmission/Teacher Focused

- High frequency practices
  - Collaborative
  - Cooperative
  - Inquiry Based/Project Based
As a scientist you don’t plan the next experiment without including information from the previous experiment, and without carefully and thoughtfully designing that experiment. It’s the same with planning your instruction.

—Richard Petersen, teacher, Beaverton, Oregon
Assessment

- **Formative** – monitoring of student learning
  - Helps students identify strengths and weaknesses in particular areas
  - Helps faculty identify where students are struggling to address the problem
  - Examples: in-class activities, feedback prompts

- **Summative** – evaluate student learning
  - Students’ work is evaluated against a standard or benchmark
  - Examples: exams, papers, projects, etc.
Forms of Assessment

- Graphic Organizers
- Interviews
- Observations
- Journals
- Examinations
- Assignments
- Presentations/Performance Tasks
- Self-Peer Evaluations
- Contracts
- Rubrics/Scoring Guides
Graphic Organizers

• Visual Organizers
  • Venn Diagrams
  • Webbing
  • Flow Chart
  • Hypercard
  • KWL

What we know
What we don’t know/
What we want to prove

Step 1
Step 2
Step 3
Interviews

- Diagnose strengths and needs
- Encourages student reflection
- Formal or informal
  - Question Suggestions
    - “Why are you doing this step?”
    - Explain why you’re choosing this approach
  - Allow for plenty of time
  - Ask students to explain their thinking process
Observations

- Used to collect data on particular behaviors
  - Attitude towards a concept or problem
  - Motivation for problem selection or method selection
  - Modeling a concept
  - Demonstrates mastery
  - Appreciates role of science
Performance Tasks

- Demonstrates students ability to apply skills and concepts
- Enhances and evaluates students’ ability to use appropriate methodologies
- Example: Interdisciplinary Projects for Differential Equations /Dynamical Systems
  - Streeter Phelps Equation to Evaluate Water Quality
  - Robotics in Human Performance
  - Harmonic Motion: Spring Load with Damping
Self & Peer Evaluations

- Used to gain information on the student’s perspective of his/her own performance (or a peer’s performance)
  - Survey
    - End of class
    - End of assessment
  - Midterm Evaluation

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<th>Problem Solving Rating Scale</th>
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<tr>
<td>1</td>
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<tr>
<td>I do not understand the problem</td>
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<tr>
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<tr>
<td>I cannot recognize the important and unimportant parts of this problem</td>
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<tr>
<td>1</td>
</tr>
<tr>
<td>I do not know where to start</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>This was a difficult problem</td>
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Comments:
More Familiar Methods

- Examinations
  - Recall of information and literal comprehension
  - Time efficient
  - Evaluates logic and the ability to make connections

- Journals/Portfolios
  - Reference guide
  - Collection of work conducted
## Forms of Assessment

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- Graphic Organizers
- Interviews
- Observations
- Journals
- Self-Peer Evaluations
- Rubrics/Scoring Guides
- Examinations
- Presentations/Performance Tasks
- Journals (Portfolio)
- Rubrics/Scoring Guides
- Assignments
Best Assessment Strategies for the Top Instructional Mathematics and Computer Science Practices
Collaborative Based Teaching

- Group/peer evaluation
  - Group submission & individual submission
  - Preset rubric for Individual Team Assessment
  - Most effective: Any type of activity

- In-class peer evaluation
  - Preset rubric or standards
  - Most effective: Live activities
Cooperative Based Teaching

- Performance Tasks
Inquiry Based/Project Based Teaching

- Identify Learning Outcomes
- Instructional Strategies:
  - Performance Tasks
    - Individual projects/ group projects
  - Group/Peer Evaluation
  - Examinations
    - Control group
- Timeline
- Most effective: Activities that cultivate organic thinking
The Assessment Process

“Instructional strategies are designed to help students attain certain types of learning outcomes.” – (Fink, 2010)

- Identify the learning outcomes
- Plan a section/unit/chapter on particular topics
- Identify and design the assessments (formative and summative) to align with the learning outcomes
- ALL OF THE ABOVE IS DONE BEFORE YOU ENTER THE CLASSROOM!!!
Resources


Assessment Strategies to Inform Science and Mathematics Instruction: It’s Just Good Teaching (1997). Northwest Regional Educational Laboratory.