NSF WORKSHOP

Development and Application of Online Medical Imaging Education

Sponsored by NSF Grant DUE1022750
Principal Investigator: Weizhao Zhao, Ph.D.

College of Engineering, University of Miami
1251 Memorial Drive, Coral Gables, FL 33146

August 16th, 2013
Final Program

8:00am   Breakfast
8:30 am  Registration, Introduction, Picture
9:00 am  Invited Presentation: Web-Based Interactive Computer Simulation and Animation for Engineering Education, Ning Fang, Utah State University
9:30 am  Medical Imaging Education by Online Animation and Simulation, Weizhao Zhao, University of Miami
10:00 am Medical Imaging Teaching Software: Ultrasound Imaging and Image Processing, Ricardo Castellanos, Diego Pava, Nurgun Erdol and William Rhodes, Florida Atlantic University
10:20 am Web Based Interactive Medical Imaging Application for Teaching Nuclear Medicine, Senait Debebe, Ruchir Bhatt, and Anthony McGoron, Florida International University
10:40 am Evaluation STEM Initiatives, Ann Bessell, University of Miami
11:00 am Discussion in THREE groups lead by PIs of FAU, FIU and UM, scribed by one participating scholar: Current medical imaging curriculum, teaching strategies, resources, and plans
12:15 pm Summary presentation of each group presented by a participating scholar
12:30 pm Lunch break
1:30 pm  Tutorial for the developed MITS/DATS system
5:00 pm  Conclusion
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Web-Based Interactive Computer Simulation and Animation for Engineering Education

Ning Fang
Department of Engineering Education
College of Engineering
Utah State University

August 16, 2013

Outline

1. My background
2. NSF TUES program
3. Web-based interactive computer simulation and animation (CSA) – a critical review
4. Demos of web-based interactive CSA learning modules
5. Concluding remarks

1. My Background

- Mechanical engineering (PhD in 1994, MS in 1988, BS in 1984)
- Research interest: technology-enhanced learning (clickers, tablet PCs, computer simulation and animation, intelligent tutoring systems, ……)
- Associate professor in the Department of Engineering Education at Utah State University
Department of Engineering Education at Utah State University

- Within the College of Engineering [http://eed.usu.edu/](http://eed.usu.edu/)
- Teach: 2nd year foundational engineering courses (Statics, Dynamics, Strength of Materials, Electrical Circuits, Computer-Aided Design, etc.)
- Research: Pedagogical research in engineering education
  - PhD in Engineering Education program: one of the only three programs in the nation
  - 12 PhD students (these students have MS/BS in engineering and are interested in educational research)

NSF/DUE STEM Programs That I Was Involved

- Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES) Program (formerly CCLI program) that aims to improve undergraduate education in STEM disciplines.
- Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) that aims to improve the recruitment and retention of STEM undergraduates.
- NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Program that provides scholarships to STEM undergraduates.
- Advanced Technological Education (ATE) Program that aims to improve technology education in community colleges.

2. NSF TUES Program

The vision of the TUES program is excellent STEM education for all undergraduate students, especially providing "transformative" learning experiences for students.

TUES Program Solicitation NSF 10-544
CAUSE (Catalyzing Advances in Undergraduate STEM Education) is an NSF-wide investment that incorporates funding from established programs in the EHR directorate and other NSF directorates funded through the Research and Related Activities (R&RA) account. It is created by consolidating three Division of Undergraduate Education (DUE) programs: STEM Talent Expansion Program (STEP), Widening Implementation and Demonstration of Evidence-based Reforms (WIDER), and Transforming Undergraduate Education in STEM (TUES); several R&RA programs: BIO’s Transforming Undergraduate Biology Education (TUBE); ENG’s Research in Engineering Education and Nanotechnology Undergraduate Education (NUE); GEO’s Geosciences Education and Opportunities for Enhancing Diversity in the Geosciences (OEDG); and the cross-NSF program, Climate Change Education (CCE).

FY 2014 NSF Budget Request to Congress

TUES Program

- Creating Learning Materials and Strategies
  - Ex: web-based, interactive learning modules
  - Ex: learning materials for mobile learning (iphone, ipad, …)

- Implementing New Instructional Strategies
  - Ex: Peer-led guided inquiry
  - Ex: Collaborative problem-based learning

- Developing Faculty Expertise
  - Ex: faculty development workshops
  - Ex: virtual community of practices

TUES Program (Continued)

- Assessing and Evaluating Student Achievement
  - Ex: assessment of students’ self-regulated learning skills
  - Ex: assessment of students’ problem-solving skills

- Conducting Research on Undergraduate STEM Education
  - Ex: How do students learn foundational engineering concepts?
  - Ex: What factors critically affect student retention?
  - Ex: How to best design web-based learning materials to optimize student learning outcomes, given diverse student populations (gender, learning styles, cultural background, …)
Three Types

- Type I: $200K, 2-3 years, typically a single institution
- Type II: up to $600K, 2-4 years, multiple institutions
- Type III: up to $5M, over 5 years, multiple institutions

Key Points

- In addition to excellent project ideas, implementation and evaluation plans, the project should:
  - Provide "transformative" learning experiences for students.
  - Broadly disseminate project results to facilitate the adoption/adaption at peer institutions.

3. Web-Based Interactive Computer Simulation and Animation (CSA) – A Critical Review
Advantages of Computer Simulation and Animation (CSA)

- Properly designed CSA helps improve students’ spatial abstract thinking skills by enabling students to visualize various science and engineering phenomena.
- Particularly attractive to many contemporary tech-savvy students as it promotes active and collaborative learning, and can be easily and widely adopted at both formal and informal education sites with no requirement for expensive physical facilities and instrumentations.

Examples of NSF-Funded CSA Projects

<table>
<thead>
<tr>
<th>Project title</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of Virtual CNC Machine Tools and Web-Based Machining Process Simulation and Learning</td>
<td>Missouri University of Science and Technology</td>
</tr>
<tr>
<td>An Inquiry-Based Simulation Learning Environment for the Ecology of Forest Growth</td>
<td>Hampshire College</td>
</tr>
<tr>
<td>Education Research Grant: Encouraging Students to Pursue Undergraduate Degrees in STEM Fields by Exposing them to Fundamental STEM Paradigms via Interactive Visual Arts Modules</td>
<td>Morehouse College</td>
</tr>
<tr>
<td>Introduction of Simulation Learning and Optimization to Support Engineering Design</td>
<td>University of Illinois at Urbana-Champaign</td>
</tr>
<tr>
<td>DIYModeling -- Do It Yourself Modeling and Simulation for STEM Learning</td>
<td>Texas Southern University</td>
</tr>
<tr>
<td>Modernizing the Undergraduate Power Engineering Curriculum with Real-Time Digital Simulation</td>
<td>Missouri University of Science and Technology</td>
</tr>
<tr>
<td>Interactive Simulation for Teaching Engineering Economics</td>
<td>Rowan University</td>
</tr>
</tbody>
</table>

Purpose of Literature Review

Purpose: understand the current status of design and implementation of computer simulation and animation (CSA) programs/modules

Scope: limited in foundational engineering mechanics courses: Statics, Dynamics, Engineering Mechanics, Strength of Materials; and several high school physics/mechanics
An Example Study

An animated motorcycle module (Stanley, 2008): Why does the acceleration vector change direction and magnitude as it moves along the trajectory?

Study Characteristics

- Student learning outcomes
- Sample size of study
- Area of study
- Authoring software
- Proprietary
- Mathematical equations
- User controls
- Other media
- Experimental design
- Data collection

Results
Suggestions

- Design of CSA programs/modules:
  - More animation controls
  - Diverse representations of information
  - Free web browser plug-ins
  - Mathematic equations
  - “Copy & Paste”

- Assessment of student learning outcomes:
  - Random assignments
  - Control group, pre and post tests
  - Diverse methods of data collection and more performance tests

4. Demos of Web-Based Interactive CSA Learning Modules

- TUES Type 2 project “Improving Students’ Problem-Solving in Engineering Dynamics Through Interactive Web-based Simulation and Animation Modules” (2011-2015)

- Phase I (1.5 years): Develop a unique set of CSA modules for both particle and rigid-body dynamics
- Phase II (2.5 years): Assess the effectiveness of the developed CSA modules using the quasi-experimental research design method: control group and treatment group.

Engineering Dynamics

- High-enrollment and high-impact, core engineering course that nearly all mechanical, civil, and aerospace engineering students are required to take.
- Covering a broad spectrum of foundational concepts and principles, such as motion, force and acceleration, work and energy, impulse and momentum, and vibration.
- One of the most difficult engineering courses to succeed in. In the Fundamentals of Engineering examination in 2009, the national average score for the Engineering Dynamics exam was only 53%.
Challenges of Student Learning in Dynamics

- Spatial abstract thinking and reasoning skills to correctly understand *what* physically happens in a dynamics phenomenon and to identify correct dynamics concepts and principles associated with that particular phenomenon.
- Analytical and mathematical modeling skills to help students translate their physical understanding into mathematical equations that accurately explain and describe *why* that particular dynamics phenomenon occurs and *how* it evolves.

Features of the New CSA Learning Modules

- Integrates visualization with mathematical modeling
- Interactive computer graphical user interface allows students to vary inputs and see how the numerical numbers in mathematical equations change, simultaneously and dynamically, as a physical object moves in a space
- Web-based and stand-alone computer software program.

Examples of the CSA Learning Modules
Demos of web-based interactive CSA learning modules

Research Question

To what extent the developed CSA modules improve students' conceptual as well as procedural knowledge (skills) of engineering dynamics?

Research Design

Quasi-experimental research design, surveys, and interviews

<table>
<thead>
<tr>
<th>Student groups</th>
<th>Pretests</th>
<th>Treatment</th>
<th>Post-tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group (i.e., comparison group)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quasi-experimental (i.e., treatment group)</td>
<td>x</td>
<td></td>
<td>o</td>
</tr>
</tbody>
</table>

Learning gain = \frac{\text{Post-test score} \% - \text{Pre-test score} \%}{100 \% - \text{Pre-test score} \%}
Student Participants

Control semester: 86 students from three departments: mechanical and aerospace engineering, civil and environmental engineering, biological engineering
Treatment semester: 94 students from the above three engineering departments

Pretest
Posttest

Preliminary Results

CSA Module 2
- Control semester: Class-average learning gain 16%
- Treatment semester: Class-average learning gain 62%

Continued

CSA Module 4
- Control semester: Class-average learning gain 21%
- Treatment semester: Class-average learning gain 69%
5. Concluding Remarks

- If designed properly, web-based interactive computer simulation and animation (CSA) programs/modules can improve student learning.
- When designing CSA programs/modules, it is suggested to consider:
  - More animation controls
  - Diverse representations of information
  - Free web browser plug-ins
  - Mathematic equations
Thanks for Your Attention!
Medical Imaging Education by Online Animation and Simulation

Weizhao Zhao, Ph.D.
Department of Biomedical Engineering
University of Miami, Coral Gables, Florida

Background: Facts

• BME education has developed as an interdisciplinary engineering training area in the last 30 years.
• Medical Imaging is a required training area in BME and almost any health care related major, e.g., medical physics, health science.
• Medical Imaging techniques are applied in clinical and research laboratories on a daily basis.
• Medical Imaging instrument is usually unavailable (even available, it is usually not accessible).


Background: Facts

BME Undergraduate Enrollment in USA Colleges (2012)

**Background: Facts**

BME Programs, Medical Imaging Courses in USA Colleges (2010)

http://mis.eng.miami.edu/survey

**Background: Resource**

EHR Directorate
Graduate Education (DGE)
Research on Learning in Formal and Informal Settings (DRL)
Undergraduate Education (DUE)
Human Resource Development (HRD)

ENG Directorate
Chemical, Bioengineering
Environmental, and Transport Systems (CBET)
Civil, Mechanical and Manufacturing Innovation (CMMI)
Electrical, Communications and Cyber Systems (ECCS)
Engineering Education and Centers (EEC)
Emerging Frontiers in Research and Innovation (EFRI)
Industrial Innovation and Partnerships (IPI)
**History: Success**

NSF CCLI DUE0127290 (2001-2004)  
“Proof of Concept”

NSF CCLI DUE0632752 (2006-2009)  
“Build a Prototype”

NSF TUES DUE1022750 (2010-2014, Current)  
“Expansion Development”

**NSF DUE 1022750**

Florida Atlantic University  
Florida International University  
University of Miami

Collaborative Development and Application of Distributable, Internet Accessible, Interactive Medical Imaging Teaching Software (MITS) and Dynamic Assessment Tracking System (DATS)

**Motivation**

- You hear, you forget.
- You see, you remember.
- You do, you understand.
- **What do you see and what do you do?**
  - A picture is worth a thousand words: you see!
  - A moving picture is even better: you see more!
  - An interactive moving picture is better than a simple moving pictures: you do too!
**Hypothesis**

Web-based interactive teaching model increases student learning gain in the field of medical imaging education, particularly for biomedical engineering students.

**Objective**

- Develop an online learning environment to help successfully deliver medical imaging curriculum
  
  **MITS**: Medical Imaging Teaching Software

- Develop an online tracking platform to evaluate teaching effectiveness and assess student learning gain
  
  **DATS**: Dynamic Assessment Tracking System

**Curriculum in UM’s BME**

- **BME330**
  - Foundation of Med Img
  - Required (Junior)

- **BME520**
  - Med Img System

- **BME521**
  - Med Img Appl
  - Image Processing

- **BME629**
  - Adv Med Img
  - Adv Recon. and Research

- **Elective (Senior or Graduate)**
**MITS: The Design**

- Course
- Modality
- Module
- Component

**MITS: Online Interactive Learning**

- MITS: teaching tool and learning environment

**MITS: Dynamically Generated Webpage**

- Modality
- Component

- Examples of dynamically generated content are provided, such as explanations and diagrams related to medical imaging modalities like X-ray, CT, and MRI.
Either you can explain the following equation and ask student to write codes to simulate CT projection…

\[
p(x', \theta) = \sum f(x \cdot \cos \theta + y \cdot \sin \theta, -x \cdot \sin \theta + y \cdot \cos \theta) \\
= \sum f(x \cdot \cos \theta + y \cdot \sin \theta, y') \quad \forall \theta
\]

And explain the following equation and ask students to write codes to simulate CT reconstruction…

\[
g(x, y) = \sum p(x', \theta) = \sum p(x \cdot \cos \theta + y \cdot \sin \theta, \theta) \quad \forall \theta
\]
DATS: Online Assessment Database

Pre-Modality Test (4~5 concept questions)
- Pre-Module Test (1~2 concept questions)
  - Module 1
  - Module 2
- Post-Module Test (1~2 concept questions)

Post-Modality Test (10~20 questions)

MODALITY 1
- Pre-Module Test (1~2 concept questions)
  - Module 1
- Post-Module Test (1~2 concept questions)

Final Review Test (40~50 questions)
**DATS: Module Information**

**Application: Hybrid Approach**

- Web-Modality Pre-test
- Web-Module Pre-quiz
- Web-Reading/Practicing
- Web-Module Post-quiz
- Classroom Lecture (Module)
- Class Homework/Project
- Web-Modality Post-test
**Animation and Simulation:**

**X-ray Modality:**
- X-Ray Tube’s working principle
- X-Ray Tube’s emission spectrum
- Inner shell ionization
- Bremsstrahlung radiation
- Compton Scattering
- Half Value Layer
- Attenuation
- X-ray Geometry

**CT Modality:**
- Pen-beam projection
- Fan-beam projection
- Back projection by degree in Radon domain
- Back projection by Cartesian coordinate
- Downloadable CT Simulation
- Numerical reconstruction

**MRI Modality:**
- Precession
- Larmor frequency and RF pulse
- MRI Relaxation
- Downloadable FID Simulation
- Downloadable Reconstruction Simulation
**Animation and Simulation:**

**Nuclear Medicine Modalities:**
- Radioactive decay through materials
- How PET works
- How SPECT works
- Radionuclide half-life
- Coincidence Sampling
- PET demonstration
- Reconstruction demonstration
- To be uploaded animations by FIU
- To be uploaded simulations by FIU

**Animation and Simulation:**

**Ultrasound Imaging Modality:**
- A-mode Ultrasound
- M-mode Ultrasound
- B-mode Ultrasound
- Doppler Effect
- To be uploaded animations by FAU
- To be uploaded simulations by FAU

**Collaboration: “Users”**
- **Contacted:**
  - University of Valencia (EE), Spain
  - University Pompeu Fabra in Barcelona (BME), Spain
  - Ariel University (MP), Israel
  - University of Western Ontario (ECE), Canada
  - Medical School Athens, Greece
  - Università degli Studi di Milano (Rad), Italy
  - Baylor College of Medicine (MI), TX
  - Duke University (CoE), NC
  - DeVry University (BMET), CA
  - Rose-Hulman Institute of Technology (MP), NJ
  - Florida Atlantic University
  - Florida International University
  - University of North Carolina (BME), NC
  - Broward College (HS), FL
- **Participating**
  - Florida Atlantic University
  - Florida International University
  - University of Miami
Application: “Protocols”

BME330: Foundation of Medical Imaging
- Primary teaching material: Textbook, Instructor’s handout
- MITS/DATS system: Reference material, volunteer
- Pre/Post test/quiz: Extra credits

BME520: Medical Imaging System
- Primary teaching material: Textbook, No handout
- MITS/DATS system: Hybrid with textbook to serve as handout material, volunteer
- Pre/Post test/quiz: for review only, NO extra credits

Results

Subjective perception information

<table>
<thead>
<tr>
<th>21 student responses</th>
<th>Rating 5 strongly agree - 1 strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The simulation protocol is well organized (*)</td>
<td>18</td>
</tr>
<tr>
<td>2. The interface of the protocol is user-friendly (*)</td>
<td>16</td>
</tr>
<tr>
<td>3. The protocol provides you ample opportunities to gain knowledge, skill and technique that traditional lecture or textbook content provide (*)</td>
<td>20</td>
</tr>
<tr>
<td>4. The visual feature stimulates your interest of learning a subject (*)</td>
<td>21</td>
</tr>
<tr>
<td>5. The physics and mathematics concepts link closely the engineering implementation (*)</td>
<td>18</td>
</tr>
<tr>
<td>6. Simulation exercises enhance your understanding to a particular modality (*)</td>
<td>21</td>
</tr>
<tr>
<td>7. Overall usefulness of the simulation protocol to current course (*)</td>
<td>20</td>
</tr>
</tbody>
</table>

Factual information

214 students (154 undergraduates) took medical imaging courses

For modality X-ray and CT (pre/post test)

<table>
<thead>
<tr>
<th></th>
<th>GPA</th>
<th>All Prob.</th>
<th>Concept Prob.</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre (n=23)</td>
<td>3.42±0.34</td>
<td>82±9%</td>
<td>76±5%</td>
<td>82±5%</td>
</tr>
<tr>
<td>Post (n=21)</td>
<td>3.46±0.44</td>
<td>89±8%</td>
<td>91±6%</td>
<td>90±6%</td>
</tr>
</tbody>
</table>

1: p < 0.7 2: p < 0.1 3: p < 0.05
**Results** Learning Gain

Result: Concept understanding quiz (BME520)

Learning Gain (2011):

\[
LG = \frac{(\text{post-pre})}{(100-\text{pre})} = 0.36 \pm 0.28
\]

**Results** Subjective perception

Result: Survey from classes (BME330/520)

Apparent subjective perception “disparity” between classes

**Results** Engagement

Result: Time used on MITS (BME330/520)

Apparent subjective perception “disparity” between classes
**Results**

Grade Impact

**Result: Midterm/Final exam (BME330)**

![Graph showing test results]

- **112:** 73.5±16 and 68.9±14 (N=12), lowest grade B (n=4)
- **121:** 69.2±22 and 63.0±27 (N=24), lowest grade F (n=1), D (n=1), C (n=3)

**Results**

Comments

**Result: Open end survey (BME330/520)**

Summary:

- Animations of the underlying physics behind modalities
- Organized well and provided visualization
- Good summary for class review
- Remote accessible, self-paced
- Practice test/quiz help review
- Format is not consistent
- Index is not clear
- Pre/post quiz does not match content/class material
- Class test questions are too difficult and some not relevant
- Too much text
- Can you put the website on Blackboard

**Conclusion**

- MITS provides an Internet accessible, interactive, module based teaching tool and learning environment
- DATS manages MITS through a database platform, provides quick feedback for teaching efficiency and assesses student learning gain dynamically
Future Work

• Seeking for collaboration to apply the system under different settings, such as BME, ECE, HS, PHY, or other curricula.

• Seeking for NSF proposal collaborators: Medical Imaging through CyberLearning

• Seeking for collaborative research on Integration of Medical Imaging into Special Applications, e.g., Medical Physics program, Health Science program

Acknowledgement


External Advisory Committee
Dr. Thomas Harris, Director NSF EEC
Dept. of Biomedical Engineering, Vanderbilt University
Dr. Autar Kaw, ASEE Distinguished Scholar 2011, US Professors of the Year, 2012
Dept. of Mechanical Engineering, University of South Florida

Graduate Students
David Wu, Aditya Dixit, Chuyuan Wu, Alan Moses, Jack Lu,
Qin Shen, Xiping Li, Decho Sunanotiarit, Wupeng Yin, Hairong Chen

NSF CCLI/TUES Program Directors
Dr. Russell L. Pimmel, Dr. Don L. Millard

http://mis.eng.miami.edu
Questions?

http://mis.eng.miami.edu
NSF National Workshop on Medical Imaging Teaching Software
University of Miami – 16 August 2013

Florida Atlantic University Modules

Ultrasound Imaging
Image Processing

Ricardo Castellanos
Diego Pava
Prof. Nurgun Erdol
Prof. William Rhodes

Medical Imaging Course Testbeds

- Fa10 Florida Atlantic University - 10 students
- Sp12 Florida Atlantic University - 12 students
- Sp12 Universidad Javeriana - 30 students
- Sp13 Universidad Javeriana - 26 students

Total of 78 students (all from engineering)
Course Text:

Medical Imaging Signals and Systems
by Prince & Links

An excellent text for students with background in engineering and physics, but short on figures in certain areas: a good candidate for augmentation with animations.

Representative Examples

Ultrasound Imaging

- Presentation by Ricardo Castellanos (Ph.D. candidate in electrical engineering)
Image Processing Innotool For Medical Imaging

A Matlab-based teaching software package and tutorial

Diego F. Pava
Florida Atlantic University

Presentation by Diego Pava (Ph.D. candidate in electrical engineering)
Web Based Interactive Medical Imaging Applications for Teaching Nuclear Medicine

Senait A. Debebe, Ruchir Bhatt, Anthony J. McGoron
Department of Biomedical Engineering, Florida International University, Miami, FL, U.S.A.

Develop interactive medical imaging applications focused in Nuclear medicine
Establish internet accessible applications
Sharable, distributable and upgradable applications
Increase students learning gain by conveying dynamic explanations.
Flexible learning schedule to fit into the available class hours.

I. PET Simulation

MATLAB® was used to simulate PET image reconstruction mechanism.
Scattering and random coincidence effects were simulated by adding Gaussian and/or Poison noise.
Radon transform was performed to generate sinogram of an image.
Filtered Back Projection algorithm was used to reconstruct the original image.
II. Tracer Kinetics Model

- The relationship among input function (Plasma activity), tissue response, model structure and rate constants was illustrated using 3-compartmental models.

- MATLAB® GUIDE has been used to develop a user interface.

- Background MATLAB program has been used to implement:

  \[ A_i = \left( \frac{\text{Input Function}}{\text{Tissue Response}} \right) \times \text{measured data by PET} \]

III. Reporter Gene Imaging

- Animation of PET reporter gene imaging was performed.

- Adobe® Flash® Professional CS5 was used together with ActionScript 3.0 to apply codes.

IV. Coincidence Detection

- Circuitry of PET coincidence detection, generation of single and multiple incidences are animated.

- Adobe® Flash® Professional CS5 was used.
V. Autoradiography

- Procedures and materials required to do Autoradiography is animated which is used determine the distribution of radioactivity.

- Adobe® Flash® Professional CS5 was used.

Results

1. PET Simulation

Activities
- Choose to add Gaussian and/or Poisson noise
- Set STD value
- Enter angle spacing between projection angle of Radon transform
- Adjust image reconstruction parameters: filter type & cutoff frequency
- Help files provided

Results Cont.

2. Choose between models

Activities
- Click on input functions (PTACs)
- Enter estimated rate constant values (Ki)
- Observe the resulting TTACs
3. Activities
- Step by step procedures are animated.
- Reporter gene injection and its route inside a liver cell is elaborated.
- Reporter probe interaction with expressed proteins/enzymes/receptors is shown.
- Start, forward and backward buttons are provided.

4. Activities
- Start button to start the animation
- Coincidence detection circuitry is animated
- Step by step explanation of signal generation
- Next button to go to the next step

5. Activities
- Start button to start the animation
- Injection and distribution of radiotracer, and technique of autoradiograph are animated
- Step by step explanation of materials and methods applied
- Next button to go to the next step
EVALUATING STEM INITIATIVES

Ann G. Bessell, Ph.D.

WHAT IS

Beyond Science, Technology, Engineering and Math

STEM education attempts to transform the typical professor-centered classroom by encouraging a curriculum that is driven by problem-solving, discovery, exploratory learning, and requires students to actively engage a situation in order to find its solution.

STEM PIPELINE FROM 9TH GRADE TO BACHELOR’S DEGREE FOR LOW-INCOME STUDENTS IN THE U.S.

- 10,000 Students in the Bottom Income Quartile Start the 9th Grade
- 6,600 of 10,000 Students Earn a High School Diploma (8,200 total)
- 3,860 of 10,000 Students Go to College
- 76 are Declared STEM Majors vs 800 total
- 710 of 10,000 Students Earn a Bachelor’s Degree in STEM Fields vs 400
THINK OUTSIDE THE BOX: PROBLEMS

1. Convert the following figure into a six by adding only one line.

[Image of IX]

2. Leave two squares in the following figure by removing just two lines.

[Image of 88]

THINK OUTSIDE THE BOX: SOLUTIONS

1. Convert the following figure into a six by adding only one line.

[Image of SIX]

2. Leave two squares in the following figure by removing just two lines.

[Image of 89]

10 ESSENTIAL STEM TEACHING PRACTICES

1. Believe in your students. Set high expectations for your students, challenge them to succeed, and believe that they will.

2. Transfer control of the learning process to the students. Develop new roles and rules that stress student responsibility. Then guide from the sidelines while keeping students on target with their direction and purpose.

3. Foster curiosity. Pose problems rather than answers and send students on a search for solutions. Use discrepant events to intrigue students and draw them into the problem.

4. Provide hands-on, experiential learning. Don’t be the old-fashioned sage on the stage. Learning through reflection and doing is compelling. When your students have their imagination piqued, give them opportunities to actually investigate multiple possible solutions to a problem, or to solve a mystery.
5. Increase collaboration among students. Get comfortable with teamwork.
6. Accept failure—both yours and the students—as a necessary part of learning and growing. That is, accept failure that accompanies taking a risk and experimenting, knowing that they might not get it right.
7. Be an inspiring leader and role model for your students. Be positive and enthusiastic about what students are learning and how they are learning it.
8. Accept some drawbacks. STEM education will improve student engagement, critical thinking skills, and workforce skills. But you’ll need to be flexible and ready to make some quick shifts in your thinking.
9. Evolve and grow as a learner. Develop your skills in facilitating (as opposed to dictating) so that students focus on learning how to think like a STEM professional.
10. Learn in community. Work with your colleagues to study effective ways of teaching STEM lessons.

REASONS FOR EVALUATION
- Performance improvement
- Outcome assessment
- Program justification
- Accountability
- Program clarification
- Cost-effectiveness

RESULTS-BASED ACCOUNTABILITY™
- Results (or outcomes or goals) as “A condition of success for students, professors, program of study, or school.” This can include some of the major junctures in a student’s education where they can continue on a trajectory toward success or fall back through the cracks.
- Indicators (or benchmarks) which are the “what” that can be measured to help quantify the achievement of an outcome. Each program needs to identify the appropriate indicators for their program by answering the question “How would we recognize these outcomes in measurable terms?”
- Performance Measures. These are the metrics that will be used to measure how well a program, course, or career path is working. Each program needs to identify the appropriate metrics for their program by answering questions like “How much did we do? How well did we do it? What are the effects/gains for the participants?”
EVALUATION PLANNING

Most STEM evaluation proposals ask for three elements but use different language:

- “Fidelity of Implementation” or just “fidelity” measures the extent to which the program activities have been accomplished.
- “Formative” or “process” evaluation provides mid-course corrections to Ps.
- “Summative” or “impact” evaluation summarizes the program’s merit and worth.

THEORY OF PROGRAM CHANGE:

- “…a static, fixed, and mechanical cause-effect model where inputs lead to outputs, which produce outcomes and impacts…”
- “Works well in simple situations of high certainty and high agreement about what to do. But such modeling has significant downsides and distorting effects in complex and dynamic situations where the program is emerging, evolving, and adapting.” MQP 2011

BASIC LOGIC MODEL
STRUCTURE OF A COLLABORATIVE

Input indicators measure resources, contributions and investments such as:

- Staff
- Volunteers
- Funding
- Materials
- Facilities

Output indicators measure things such as the scope/size of activities, services, events, and products reaching the target population:

- Numbers of students served
- Number of simulations completed
- Number of courses
- Numbers of workshops
PROCESS

INPUTS

OUTPUTS

UNPACKING THE BLACK TUBE

- Usability methods
  - Cognitive interviews "Think Alouds"
- Focus Groups
  - Satisfactions
  - Challenges
  - Successes
- Observations
- Surveys

OUTCOMES

Things project hopes to achieve; actual benefits, impact, or changes. Outcomes are expressed in terms of changes for individuals, groups, communities, institutions, and system:

- Knowledge, attitude, and skill changes
- Behavior changes
- Value changes
- Policy, procedural, and practice changes
CONSIDERING BP SUCCESS AT MULTIPLE LEVELS

Level 1: Having access to the benefits of STEM knowledge
Level 2: Having access to STEM knowledge
Level 3: Studying STEM
Level 4: Working in STEM areas
Level 5: Generating STEM knowledge

11. ON A SCALE OF 1 TO 10, HOW SATISFIED ARE YOU WITH YOUR SIMULATION EXPERIENCE?

1. 1 (lowest)
2. 2
3. 3
4. 4
5. 5
6. 6
7. 7
8. 8
9. 9
10. 10 (highest)

BRIEFS AS A WAY TO DISSEMINATE

BUSINESS PARTNERSHIPS TO ADVANCE STEM EDUCATION:
Building a Bridge to Homegrown STEM Talent
Focus on Teachers
MITS/DATS TUTORIAL

Website: http://mis.eng.miami.edu/

Start webpage

Interactive Medical Imaging Simulation

Adobe Shockwave or Flush should be installed before use.

Click here to get onto the main page
MIS Website: http://mis.eng.miami.edu/module/mis.php

1. Home
2. User Login
4. Img Modalities

1.1. Self-Link
1.2. Other BME
1.3. Img Manufac
1.4. Design
1.5. Announcement and contact
1.2. Link to other BME: http://mis.eng.miami.edu/Files/SD2-1.pdf

1.3 Link to Img Manufac: http://mis.eng.miami.edu/Files/SD3-1.pdf
1.4. Design Outline: [http://mis.eng.miami.edu/Files/SD5-1.pdf](http://mis.eng.miami.edu/Files/SD5-1.pdf)


2.1. First time login

2.2. Normal login

2.1. set up user ID and password for future login

2.1. Other information for focused groups

3. Admin Login: [http://mis.eng.miami.edu/admin/m.php](http://mis.eng.miami.edu/admin/m.php)

3. Administrator login

3. 1
3. 2
3. 3
3. 4
3. 5
3.1. Add Users

Usr ID: (better specified)
Any character sequence without space in between
Line break for difference user ID

Condition information for future data retrieval

3.2.1. User Management

Check “Use Condition” can extract users meeting the conditions.
Uncheck “Use Condition” will extract all previously registered users.

Check “Match Case” can extract specified users ignoring conditions.
3.2.2. User Management

View specified user’s “engagement” with the system.

3.2.3. User Management → View
3.2.4. User Management → Report

Output specified user’s “performance” in each module.

3.2.5. User Management → Reset

When “reset” a user, user ID remains but the user must go through “first time” login to create password.
3.2.6. User Management → Delete

When “delete” a user, user ID and user performance information can be deleted individually.

3.3. Modality Management

To allow user to access specified “Modalities”

To determine the number of post-test questions for users.
3.4. Module Management

To allow user to access specified “Modules” within each Modality

3.5. Change Password

Administrator/Instructor’s Password should be changed at the first time login.
4. MIS Website: [http://mis.eng.miami.edu/module/mis.php](http://mis.eng.miami.edu/module/mis.php)

4.1. Hierarchical Design

**Course**
- Graduate, undergraduate, etc.

**Modality**
- Available, specified, etc.

**Module**
- Hardware/software, physics, engineering, etc.

**Component**
- Text, figure, animation, simulation, etc.
4.2. Learning Assessment

Pre-Modality Test (4~5 concept questions)

Pre-Module Test (1~2 concept questions)
Module 1
Post-Module Test (1~2 concept questions)
Pre-Module Test (1~2 concept questions)
Module 2
Post-Module Test (1~2 concept questions)

MODALITY 1
Post-Modality Test (10~20 out of ~40 questions)

Final Review Test (40~50 out of ~100 questions)

4.3. Example

Modality
Module
Text component
Fig component
4.3. Example

Animation component

Downloadable Simulation component
Go through an Imaging Modality

Step 1: Administrator Login
Step 2: Create User Account

- Administrator login
- Add user
- Log out when done

Step 3: User Login

- User login
- Or click any Imaging modality
Step 3: User Login

First time login must go through this step!

Step 4: User Information

Password will be remembered by the system!
Step 5: Go through CT Modality: Pre-Modality Assessment

Check student’s science/engineering background.

Step 6: Go through CT Modality: Pre-Module 1 Assessment

Check student’s science/engineering background for the current topic.

System gives the correct answer.
Step 7: Go through CT Modality: Module 1

This module mainly uses slide presentation.

Step 8: Go through CT Modality: Post-Module 1 Assessment

System gives the correct answer. Click Next to proceed to next module.

This post-quiz question is usually the key concept for the module.
Step 9: Go through CT Modality: Pre-Module 4 Assessment

Step 10: Go through CT Modality: Module 4

This module presents some equations.

This module presents some animations.
Step 11: Go through CT Modality: Module 4 (Projection)

CT projection animations (pen-beam and fan-beam) can be played directly.

Step 12: Go through CT Modality: Module 4 (Back Projection)

CT back-projection animations (coordinate-based and angle-based) can be played directly.
Step 13: Download Executable Simulation created by MatLab

Step 14: Executable Simulation (FID)
Step 15: Executable Simulation (FID)

Step 16: Executable Simulation (MRI)
Step 17: Executable Simulation (MRI)

Step 18: Go through CT Modality: Post-Modality Assessment

This box will always stay here when all modules are learned.

Assess student's learning gain after learning this modality.
Step 19: Go through CT Modality: Post-Modality Assessment

Every question must be answered to complete the assessment.

Deficits? Answers are not provided to user but to Instructor.

Step 20: Track Student Performance

Log out first

Then administrator login
Step 20: Track Student Performance

Select “View” to see User’s “engagement” with the system.

Go to User Management

Step 21: Track Student Performance

View provides report of User’s each “engagement” by clicking the user name on the left.
Step 22: Track Student Performance

Performance on assessment questions for Pre-post Modality and Pre-post Module are reported here.

Left column is user’s answers.
Right column is correct answers.

Step 23: Track Student Performance

Select “Report” to see User’s numerical data with the system.
 Administrator is a “User”
 Modalities are “Parallel”
 Modules are “Sequential”
 User Manual is attached
 System will be updated continuously
 Correction and revision are welcome
 New development are very much welcome
Instruction to MITS/DATS online courseware

MITS: Medical Imaging Teaching Software
DATS: Dynamic Assessment Tracking System

MITS/DATS is designed for medical imaging education as an online courseware that is particularly used under a hybrid teaching/learning environment. The courseware consists of five commonly used medical imaging modalities (X-ray, CT, MRI, PET, and Ultrasound) and commonly used image processing tools (under construction). Each imaging modality consists of six basic components to deliver knowledge to students, 1) text description, 2) figure/picture/image illustration, 3) interactive animation, 4) interactive simulation, 5) pre-post assessment and 6) library of medical imaging application (under construction).

Each imaging modality in MITS contains several teaching modules (teaching/learning topics). DATS is a database under MySQL environment. DATS is the “manager” of MITS. DATS controls turning on/off modalities, modules, assessment questions and user enrollment.

Home page: http://mis.eng.miami.edu/module/home.php,
On the home page, we provide
Links to Other BME Program in USA (updated 2009)
Links to Medical Imaging Manufactures (updated 2009)
Links to Imaging Simulation Flow Charts (updated 2008)

Announcement: updating news for MITS/DATS
Intern Students: application for internship
Participating Institution: application as a user-institution
Faculty Workshop: application for attending NSF-funded workshop

From the home page to the MITS page, either click the MIS Webpage or enter the MITS address
http://mis.eng.miami.edu/module/mis.php

see captured screen:

Note that the MIS link is a webpage under the MITS/DATS home page
Login as Administrator/Instructor

Go to the bottom of the page (home page or MIS page)

Click “Admin”, enter your username and password, it will link you to the administrator login page. Administrator/instructor can do following:

1) Add Users
2) User Management
3) Modality Management
4) Module management
5) Change Password

The interface is displayed as following:

You can select the tools listed above to manage the system.
Add Users:

Administrator/instructor can add users through the window provided by the system. You should first specify “Year”, “Semester” and “Class” first (for easy future retrieval).

Year is a 4-digit number.
Semester is selected from the dropdown list (Fall, Summer, or Spring).
Class is course code, such as BME300, ECE400.

These entries will be associated with the users for assessment. Administrator/instructor can retrieve user’s performance or engagement through the information.

Username can be entered in the provided window separated by line break (return key) if more than one username entered. Username can be any more-than-two character string. Email address can also be username. Administrator/instructor can enroll multiple users, who belong to the same Year/Semester/Class, in one window/time.
User Management:

In order to manage a user, administrator/instructor must select the user(s) first.

Selecting user(s) can use the “condition” searching provided while enrolling users (year/semester/class) by typing part of the username (or *) in the space, or uncheck the option by typing part of the username (or *). If “Use Condition” is unchecked, the specified user (username) or all users satisfying wildcard * will be displayed.
Once the user(s) is retrieved, administrator/instructor can select a specific user. For example,

<table>
<thead>
<tr>
<th>ID</th>
<th>Username</th>
<th>Group</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>site_admin</td>
<td>Admin</td>
<td>[View] [Report] [Reset] [Delete]</td>
</tr>
</tbody>
</table>

Administrator/instructor can do following management to the user:

- **View**: engagement of the user to MITS/DATS, (duration of login, pre-post test, etc.)
- **Report**: output user’s all information
- **Reset**: reset user’s password to be “blank”, when user login, just feel the password
- **Delete**: remove the user from the database
Modality Management:

This management option is provided to administrator/instructor to control each imaging modality’s availability to user (student) in accordance with the teaching/learning progress.

Administrator/instructor can do following management to the user:

Enable or disable an imaging modality to users (students).
Enter a message to for the closed modality(ies).
Determine the **number of post quiz questions** from the quiz question pools. The number of post quiz questions is the same to each user but not identical because the quiz questions are randomly selected from the question pools.
Add more quiz questions to the question pools (under construction).
Module Management:

This management option is provided to administrator/instructor to control each module (teaching/learning topic) within an imaging modality’s availability to user (student) in accordance with the teaching/learning progress. For example, entry level imaging class does not need “reconstruction” modules in the CT modality.

Administrator/instructor can check/uncheck selected modules and then click Modify button.

Please note that “module” is under “modality” so that if the modality is closed, users (students) will not be able to see any module within the modality no matter the module is checked or unchecked.
Change Password:

Administrator/instructor can change his/her own password.

Please note that this function is set for administrator/instructor. A user’s password can also be reset. That function is under the “User Management” option.
Login as User

After Administrator/instructor has added a user to the system, the user can login from two places:

1) The “Login” link at the bottom of the page

2) The MIS page: http://mis.eng.miami.edu/module/mis.php, click any imaging modality

User will see a login prompt as following:

If this is the first time the user uses MITS/DATS, he/she must click top “HERE” button to setup his/her account (including password). Without this account setup, MITS/DATS will not recognize the user.
The “HERE” button links the account setup prompt window. A first-time user needs to fill in required information.

**Student ID** is the **username** entered by the administrator/instructor. A valid email address is required too. Password is a more than 6-character string. Other information is self-explained.

Once the user sets up his/her account, he/she can use the **username (student ID) with the same password to login**. Student ID login is to use the username to login. The password is the same for both. If he/she forgets the password, the administrator/instructor can go to “User Management” to “Reset” his/her password. Password becomes blank now! The user can then simply enter his/her username or email and fill in a new password to login.

Please note that **Administrator/instructor is also a User**. Following description is applied any user. A simple practice is that the administrator/instructor creates a user account for him/her-self first and uses the user account to browse the courseware.
Considering that each institution may have a different teaching schedule, imaging modalities in MITS/DATS system are “independent” each other. Our teaching/learning sequence is as follows: X-ray, CT, MRI, NMI (PET), and Ultrasound. Administrator/instructor can open the imaging modalities one by one based on teaching/learning schedule (this is our hybrid teaching practice) or open all imaging modalities at the same time.

As administrator/instructor, one should browse through all pages to have a general idea of how the system is composed before assign it to students.

When a user enters any imaging modality, he/she will pass through following learning steps

- Modality pre-test (about 5 questions) to exam user’s pre-knowledge
  - Module 1 pre-quiz (1~2 questions) to exam user’s background for the module
  - Contents of Module 1
  - Module 1 post-quiz (1~2 questions) to exam user’s understanding for the module
  - Module 2 pre-quiz (1~2 questions) to exam user’s background for the module
  - Contents of Module 2
  - Module 2 post-quiz (1~2 questions) to exam user’s understanding for the module
  - …
  - Module n pre-quiz (1~2 questions) to exam user’s background for the module
  - Contents of Module n
  - Module n post-quiz (1~2 questions) to exam user’s understanding for the module

- Modality post-test (the number of questions is set by Administrator/instructor in Module Management)

- Modality pre-test
- … …
- Modality post-test

Within each imaging modality, a user (student) must go through the steps sequentially (we consider the modules are logically designed in such sequences. We understand that different institutions may have different methods to deliver the contents for the teaching modules. We just follow the commonly used approach.

After the user finishes all modalities, he/she can go to the Final Review section where a combined review test is given. The number of final review questions is controlled by administrator/instructor (under Modality Management)

All pre/post quizzes within a module, pre/post tests within a modality and final review test appear one time only. After a user submits the post-quiz question, the module becomes “open” to the user (he/she can access the module any time later).
As introduced in the beginning, the contents of each module include

1) text description  
2) figure/picture/image illustration  
3) interactive animation  
4) interactive simulation  
5) pre-post assessment  
6) library of medical imaging application (under construction)

1) and 2) can be used as class handouts. Interactive animation is the “cartoon” type presentation, mainly used to describe physics or chemistry/biology principles. Interactive simulation is the “real” engineering process behind the screen for image reconstruction or other processing. 5) can be used to assess students’ performance or used as test practice. 6) can be used as demonstration examples (this function is under construction).

The MITS/DATS system is updated on a semester basis. Three institutions are developing this system together. In terms of imaging modalities,

Florida Atlantic University (FAU) works on Ultrasound imaging modality  
Florida International University (FIU) works on NMI (PET) imaging modality  
University of Miami (UM) works on X-ray, CT and MRI imaging modalities

The updates include text/figure revision, animation revision and addition, simulation revision and addition. We plan to develop 40 to 50 animation simulations (10 animations have been embedded, Aug. 2011) and 5 to 10 simulations (2 simulations have been embedded, Aug. 2011) to the system. The progress and other announcement will be announced at the MITS/DATS homepage.

We very much appreciate your feedback on any issue related to the system. Our goal is to create an efficient hybrid teaching/learning environment to deliver medical imaging education to students.