Teaching Nanotechnology with Technology: from technology to psychology

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Physics Department
Missouri S&T
Outline

• Why I am doing this
• Missouri Alliance for Collaborative Education (MACE)
• Content delivery options
• Course scope and target audience
• Course structure and evaluation
• Student participation (statistics)
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From the Lab to a Classroom

The Project on Emerging Nanotechnologies

Undergraduate Course:
“An Introduction to Nanostructures”
via Missouri Alliance for Collaborative Education
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• Summary of the 1st Missouri Physics Collaboration meeting held Friday, December 3, 2010 at the Department of Physics building at the University of Missouri, Columbia.

• In attendance:

  Peter Pfeifer, University of Missouri, Columbia
  Bernard J. Feldman, University of Missouri-St. Louis
  Dan G. Waddill, Missouri S & T
  Robert C. Riggs, University of Missouri-Kansas City
  Sunder Balasubramanian, Lincoln University
  Ian Lindevald, Truman State University
  Dave Probst, Southeast Missouri State University
  Roger Chelf, Missouri Southern State University
  David M. Cornelison, Missouri State University
• Participation in the collaboration is strictly voluntary. A department may decide to participate in all, some or none of the collaborative courses. By participating as a receiving institution, there is no obligation to be an offering institution.

• In the Fall of 2011, Dr. A. Yamilov of the Missouri S & T will offer a course to all Missouri public universities on Nanostructures: An Introduction. In the Spring of 2012, Dr. David Probst of Southeast Missouri State University will offer a course on Optics.

• Students at receiving universities will register at their home institutions and pay tuition for these courses to their home institutions. No money will be transferred between universities. Each department is responsible for creating a course number, title and description for their own catalogue, schedule and student transcripts.
• Each receiving university will appoint a faculty member from their own department who will have a role in the administration of the course. At a minimum, this faculty member will deal with arranging and proctoring exams, student complaints and grievances, technological problems, and advising of their own students.

• The students will be bound by all the rules and dates of their home institution, including admission and drop rules and dates.

• The academic calendar and technology used for these courses will be chosen by the institution offering the collaborative course, in consultation with the other institutions.
• All the students in these collaborative courses will be evaluated. The evaluation questions and process will be determined at a later date through an exchange of emails.

• The second Missouri Physics Collaboration meeting will be held no later than December, 3, 2011.

• The instructor of the collaborative course will grade all homework and exams and determine the final grades for all students participating in the class, using the same standard for all students.
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WebEx through Video Communication Center:

- HD video of you with ppt slides in the background (as in weather broadcast)
- A technician is always present and controls the camera
- A write-on monitor for comments and annotations
- Live broadcast and recording
- Department pays ~6K to run the course
- Students pay ~3K (1K per credit)
- Kickbacks to the department and then on to the faculty

Not an option
Wimba (Collaborate, now Tegrity) addon in Blackboard through Education Technology (EdTech)

• Low-res video feed of you with (imported) ppt slides in a separate window
• No technician, you are in full control (scary part)
• A webcam and write-on monitor for comments and annotations
• Live broadcast and recording (mp4)
• No extra costs to the department except for supplying the gadgets (~2.5K one time)
• Students pay standard fees per credit hour the their home institution
• No financial incentives to the faculty

Great option
“Wimba” option

+ +

OR

+ +
• Why I am doing this
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I: Nanoscale Fabrication and Characterization
1. Nanolithography
2. Self-Assembly And Self-Organization
3. Scanning Probe Microscopes

II: Nanomaterials and Nanostructures
4. The Geometry of Nanoscale Carbon
5. Fullerenes
6. Carbon Nanotubes
7. Quantum Dots
8. Nanocomposites

III: Nanoscale and Molecular Electronics
9. Advances In Microelectronics
10. Molecular Electronics
11. Single Electron Transistors

IV: Nanotechnology in Magnetic Systems
12. Nanostructures For Quantum Computation
13. Magnetoresistive Materials And Devices
14. Nanotechnology In Magnetic Storage

V: Nanotechnology in Integrative Systems
15. Introduction To Integrative Systems
16. Nanoelectromechanical Systems
17. Micromechanical Sensors

VI: Nanoscale Optoelectronics
18. Quantum-Confined Optoelectronic Systems
19. Organic Optoelectronic Nanostructures
20. Photonic Crystals

VII: Nanobiotechnology
21. Biomemetic Nanostructures
22. Biomolecular Motors
23. Nanofluidics
Goals of the course:
- To overview field of nanotechnology with an emphasis on physical phenomena involved
- Lay a foundation for a research career in the rapidly growing area of nanotechnology
- Enhance students competitiveness on job market

Target audience
- Upper-level undergraduates
- Graduate student in the related area (to broaden their knowledge of the field)

Challenge – different level of preparedness
- Students from UMC, S&T, UMSL, MSU, SEMO, Truman enrolled
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Meeting time:
M/W/F: 9:00am – 9:50am (recorded lectures available 24/7)

Room:
All lectures will be broadcast online and recorded
The recordings can be viewed at students’ convenience
S&T’s students can attend the class in person in room Physics 127

Textbooks:
1. “Introduction to Nanoscience and Nanotechnology”
2. “Introduction to Nanoscale Science and Technology” (do not buy)

Instructor:
Dr. Yamilov, yamilov@mst.edu Tel: 573-341-6793 Office: Phys117, S&T
Office hours: Interactive online help sessions TBA
Components of the course:

- **Homework** (2 lowest out of 12 dropped) 30%
- **Presentation** 10%
- **Presentation reviews** 10%
- **Two midterm exams (each)** 16.7%
- **Final exam** (Not cumulative) 16.7%
Homework:

• During each Friday class (excluding the weeks before the midterms and the final exams) you will be assigned a problem or a test-bank question related to the material discussed during current week
• Neatly handwritten or typed solutions are due on the Wednesday lecture of the following week
• Off-campus students submit homework solutions via email (in Word or PDF)
• Homework will be accepted only until the end of the class on the following Friday (with 20% penalty for turning the assignment after the deadline)
• There will be 12 homework assignments during semester
• At the end of the course two lowest homework grades will be dropped
Midterm and final exams:

- Midterm exams will be given on Mondays during regular class.
- Final exam will be given during the finals week, exact date/time TBA.
- Final exam will only include the material covered after the midterms.
- Both the midterm and the final tests (60 min) will consist of 4 questions.
- Test questions will be drawn from test bank available to all students.
- On-campus student will take the test in class.
- Off-campus students will need to arrange for a faculty sponsor who would (i) administer the test; (ii) ensure the test security; (iii) transmit the test to me for grading.

Test makeup policy:

- In exceptional cases of documented medical or personal emergencies, a makeup test will be provided.
- A makeup test will be composed using the same guidelines as the test missed.
1.1 Sketch and describe diagrams for the three modes of printing in photo-lithography technique. For each mode, list at least two advantages and two disadvantages.

1.2 List three factors which limit optical resolution in photo-lithography. Describe practical approaches to reducing each factor. What is the approximate numerical value of each factor in the current state-of-the-art photo-lithography?

1.3 Describe the physical principles behind the following three approaches to improving the resolution in photo-lithography: (i) Phase Shift Mask; (ii) Optical Proximity Correction; (iii) Immersion.

1.4 Describe the components and their functions in projection electron-beam lithography. List two advantages and two disadvantages of the E-beam technique in comparison to photo-lithography.

1.5 Describe the components and their functions in X-ray lithography. List two advantages and two disadvantages of the X-ray technique in comparison to photo-lithography.
Presentation:

• Every student will be asked to prepare one 15 minute narrated PowerPoint presentation. You will be notified one week before your presentation is due

• You are free to suggest a topic related to your area of interest/research

• Narrated (after composing the slides, practice your narrative and then choose Slide Show/Record Narration) PowerPoint presentations will be made available to all students via Blackboard

• Your presentation should contain the following parts:
  (i) Brief history of the subject of your presentation;
  (ii) Detailed description of the subject;
  (iii) Describe how it enabled (or was enabled by) an advancement in nanotechnology;
  (iv) Possibly, how it is being used in our every-day life;
  (v) Bibliography used in preparing your presentation.
<table>
<thead>
<tr>
<th>Campus</th>
<th>Presentation topic</th>
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<tbody>
<tr>
<td>S&amp;T</td>
<td>Clay Nanocomposite Materials</td>
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<tr>
<td>SEMO</td>
<td>Synthesis of magnetic nanoparticles for biomedical applications</td>
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<tr>
<td>Truman</td>
<td>Nanorobotics</td>
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<td>Mizzou</td>
<td>Energy storage in carbon materials</td>
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<tr>
<td>S&amp;T</td>
<td>Quantum Computer</td>
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<tr>
<td>Mizzou</td>
<td>Hydrogen bonding and self-assembly in nature</td>
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<td>Mizzou</td>
<td>Boron Neutron Capture Therapy</td>
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<td>Mizzou</td>
<td>Gecko-nanotechnology</td>
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<tr>
<td>S&amp;T</td>
<td>Self-healing nano-paint</td>
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<tr>
<td>UMSL</td>
<td>Nanostructures of stained glass</td>
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<tr>
<td>UMSL</td>
<td>Quantum Dots</td>
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<tr>
<td>Mizzou</td>
<td>Mass Production and Potential Applications of Graphene</td>
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<tr>
<td>UMSL</td>
<td>Nanocomposite materials</td>
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<td>SEMO</td>
<td>Cancer treatment and controlled drug release with magnetic nanoparticles</td>
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<tr>
<td>UMSL</td>
<td>Nano encapsulation</td>
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<tr>
<td>S&amp;T</td>
<td>Nanoparticles in petroleum engineering</td>
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<tr>
<td>MSU</td>
<td>Biometrics</td>
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<tr>
<td>S&amp;T</td>
<td>Bioengineering artificial muscles</td>
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<tr>
<td>SEMO</td>
<td>Nano-medicine</td>
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• 11000 “clicks”:
11000 / [19 users] / [120 days]  ~ 5 clicks / per user / per day
• 11000 “clicks”:

\[
\frac{11000}{[19 \text{ users}] / [120 \text{ days}]} \approx 5 \text{ clicks / per user / per day}
\]
Students embraced “question data-bank” testing strategy
95%, 86% and 92% average on three tests

Tests which cover ~5 chapters are closed-book, closed-notes type – encourages concept building (memorization is not a viable strategy)

Overwhelming participation in student presentation discussion forums

90% homework submission rate (web access suggests that the ability to access prior lectures is a major factor)

Final grades show high level of success:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Count</th>
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<tbody>
<tr>
<td>A</td>
<td>12</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
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<tr>
<td>C</td>
<td>1</td>
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<tr>
<td>D</td>
<td>0</td>
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<tr>
<td>F</td>
<td>1</td>
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