Developing a Research-Based Interdisciplinary Physics Course for Biologists

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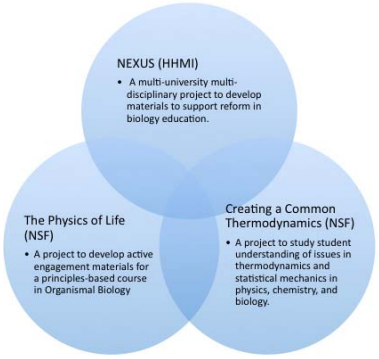
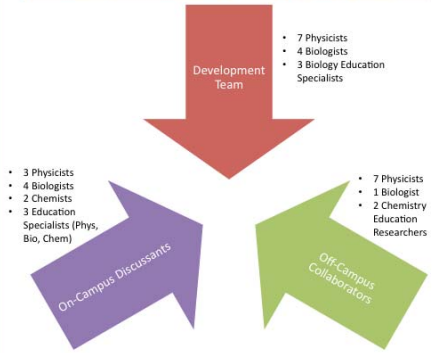
Interdisciplinary Efforts at UMd



A Team of Interdisciplinary Experts



Design Approach to an Interdisciplinary Course

- Redesign the physics for biologists course so that it is relevant for biology students – in both content and skill development [1,2]
- Include biological examples in which students see the use (and methods) of physics as helpful in helping them make sense of something important in biology
- View the development as an iterative process where data and reflections of experts inform what we do in the next iteration
- Maintain critical components – quantification, mathematical modeling, mechanism, multiple representations and coherence (among others)

Change of Topics from a Traditional Introductory Physics Class

Biology components of HW Assignments

Semester 1

Worm / How Big is Protein	Moving through a cell /Listeria	Blood and Breath	Para-mecium	Exam Review	Wood-pecker	Water coat force / DNA charge	PIP2	Arteries / Speed of blood	Exam Review	None	Bound States / Deeper Well	Muscle Contract / Thermal-chemical	Diffusion
Math	Kinematics	Dynamics		Exam 1	Dynamics		Macro	Energy	Exam 2		Thermodynamics		
Math Problems	Cat & Antelope	Force Problems	Friction Problems	Motion in 2D	Electric Forces (Balloons)	Electric Forces (clickers)	Buoyancy Force Problems	Elastic Collisions	Protein Unfolding	Energy Skate Park	None	Temp. Regulation	Micro-states

Biology-linked Group Problem-Solving Tasks

Include atomic and molecular examples from the beginning

Expand the treatment of thermodynamics

Biology components of HW Assignments

Semester 2

PE analogs for chem. rxns	Polymer folding / Evolution	Evap. Membrane	Analyzing Dipoles	DNA Shielding	Nerve Cells	No assignment	No assignment	None	Waves on an axon	None	None	Micro-scope	DNA and photons
Intro	Thermo	Electricity				Exam 1	Waves			Light	Ex 2	Light	
Kinesin	Membrane 1	Membrane 2	Electro-phoresis	Big Square	DNA Salting Out	Circuits	Diatomic Vibrations	Pulse Tutorial	Ultrasound	Mirrors	Pulses and SHO	Models of Light	Vision

Biology-linked Group Problem-Solving Tasks

Eliminate rotations, angular momentum and magnetism

Include discussions of kinetic theory, diffusion, and randomness

Goals for the Course

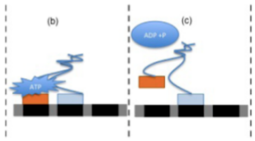
Coherence-seeking between
- Physics topics
- Physics and biology
- Physics and everyday knowledge

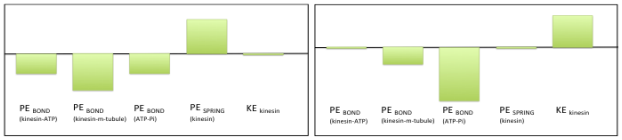
Meta-representational competence
- Choosing when to make representations
- How do representations display information

Modeling
- Understanding when to make assumptions and simplify
- What are the limitations

Example Task

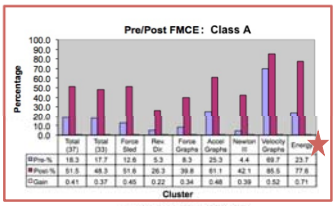
Use energy bar charts and the principle of conservation of energy to keep track of changes in energy and to explain where the kinetic energy comes from in kinesin, a motor protein.



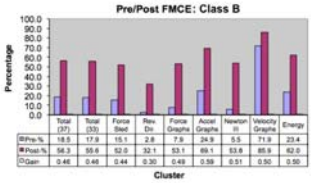


Findings from Student Learning

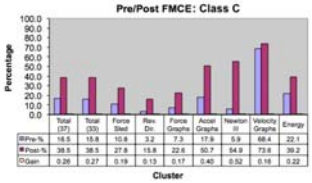
Class A. The NEXUS development test class:
In this class, recitation sections were used for group problem solving, often with biological content. Treatment of forces received reduced emphasis, with, for example, projectile motion reduced to one day's discussion. Treatment of energy received increased emphasis. (Fall 2011, N = 19)



Class B. The LHtLS class:
In this class (Learning How to Learn Science), recitation sections were used for intuition-building concept-oriented tutorials. The instructor had many years of experience teaching this class and was one of the tutorial developers. He integrated tutorial concepts into lectures, homework, and exams. The content was traditional and not adjusted to match the needs of biology students (though some biologically oriented examples were included). (Fall 2010, N = 185)



Class C. The enhanced traditional class:
In this class, recitation sections were used for intuition-building concept-oriented tutorials. The instructor was teaching this class (and any large lecture class) for the first time. It was his first time working with tutorials, but he "bought in" and attended training sessions.



Despite the absence of tutorials, Class A still beat Class C in every category. While it did not do quite as well as Class B in many categories, it far exceeded Class B in energy.

See our other posters for some interesting research results:

PST2A10: Examining the Positioning of Ideas in the Disciplines, Vashti Sawtelle
PST2A59: Research on Coherence Seeking Across Disciplinary Boundaries, Chandra Turpen
PST2A60: Research on Students' Reasoning about Interdisciplinarity, Benjamin Geller
FD07: Research on Students' Interdisciplinary Reasoning about ATP, Benjamin W. Dreyfus

References
[1] National Research Council (US). Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century, Bio 2010: Transforming Undergraduate Education for Future Research Biologists (Natl Academy Pr, 2003).
[2] Scientific Foundations for Future Physicians: Report of the AAMC-HHMI Committee (AAMC/HHMI, 2009).
[3] A. Elby et al., *Open Source Tutorials* (UMd, 2008).

Acknowledgments
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