RESOURCES FOR RESEARCH-BASED INSTRUCTION IN UPPER-DIVISION PHYSICS

Bethany Wilcox
Marcos Caballero, Stephanie Chasteen, Ben Zwickl, Charlie Baily, Steven Pollock
Upper-Division Course Transformation
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- Faculty dissatisfaction
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- Leverage techniques from introductory courses
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- Unique aspects
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• Unique aspects
  • Highly selected group of students
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• Unique aspects
  • Highly selected group of students
  • Sophisticated physics content
  • Significant emphasis on mathematics
Upper-Division Course Transformation

• Faculty dissatisfaction

• Leverage techniques from introductory courses

• Unique aspects
  • Highly selected group of students
  • Sophisticated physics content
  • Significant emphasis on mathematics
  • Relatively little research
Model for Transformation

The Science Education Initiative at the University of Colorado
Model for Transformation

SEI

The Science Education Initiative at the University of Colorado

What *should* students learn?
Model for Transformation

What *should* students learn?  What *are* students learning?
Model for Transformation

What should students learn?

What are students learning?

Which instructional approaches improve student learning?
Model for Transformation

- Establishment of consensus learning goals
  - Faculty collaboration

- What should students learn?
- What are students learning?
- Which instructional approaches improve student learning?
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- Establishment of consensus learning goals
  - Faculty collaboration
- Development of validated conceptual assessments
- Investigation of students’ difficulties
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- Establishment of consensus learning goals
  - Faculty collaboration
- Development of validated conceptual assessments
- Investigation of students’ difficulties
  - Exam/homework solutions
  - In-class/help room observations
  - Think-aloud interviews
Model for Transformation

- Establishment of consensus learning goals
  - Faculty collaboration

- Iterative design of curricular material

- Development of validated conceptual assessments
- Investigation of students’ difficulties
  - Exam/homework solutions
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Model for Transformation

- Establishment of consensus learning goals
  - Faculty collaboration

- Iterative design of curricular material
  - Interactive engagement
  - Sustainable & replicable

- Development of validated conceptual assessments

- Investigation of students’ difficulties
  - Exam/homework solutions
  - In-class/help room observations
  - Think-aloud interviews
Courses

• **Electricity and Magnetism 1**
  • Textbook: Griffiths (chapters 1-6)

• **Quantum Mechanics 1**
  • Textbook: Griffiths
Courses

• Electricity and Magnetism 1
  • Textbook: Griffiths (chapters 1-6)

• Quantum Mechanics 1
  • Textbook: Griffiths

• Electricity and Magnetism 2
  • Textbook: Griffiths (chapters 7-12)

• Classical Mechanics & Mathematical Methods 1
  • Textbook: Taylor, Boas
Courses

• Electricity and Magnetism 1  
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• Quantum Mechanics 1  
  • Textbook: Griffiths

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• Advanced Optics/Modern Physics Lab
Resources
Resources

- Consensus learning goals
- Conceptual assessments
- Banks of clicker questions
- Suites of Tutorials
- In-class activities
- Student difficulties
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All materials are freely available online

http://www.colorado.edu/sei
Resources

Consensus learning goals
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General course scale goals
- Math/Physics connection
- Visualization
- Problem solving techniques/strategies
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Tailored course scale goals
- Classical Mechanics – solving ODE’s, using computational tools
- E&M 2 – emphasis on proofs/derivations
- Optics Lab – modeling of physical systems and measurement apparatus, experimental design, technical lab skills
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Content specific goals
Resources

Conceptual Assessments
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Colorado Upper-division Electrostatics (CUE) Diagnostic
- Covers electrostatics and magnetostatics
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Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS)
- Targets students’ attitudes about lab courses and experimental physics
Evidence for Success
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Electrostatic assessment scores for Standard Lecture-based courses vs. courses using our Research-based materials
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Evidence for Success

Reforms have been sustained for multiple semesters at CU
## Evidence for Success

Reforms have been sustained for multiple semesters at CU

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Evidence of Success

Positive feedback from faculty and students
Faculty comment: “I’m glad those resources have been invested, because I can see them paying off. It lets me teach this class with the transformed materials in these new ways without taking that much more time that it would have otherwise, which was nice for me, the untenured professor who has a lot of things to do.”
Ongoing & Future Work
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- Refinement and validation of conceptual assessments
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• Further investigations of students’ difficulties
  • A framework for the use of mathematics in physics is being refined and implemented to study mathematical difficulties
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• More coherent reforms across courses are needed
  • Common student difficulties across upper-division courses
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  • A framework for the use of mathematics in physics is being refined and implemented to study mathematical difficulties

• More coherent reforms across courses are needed
  • Common student difficulties across upper-division courses
  • Differing levels of preparation from semester to semester undermine the process of building on previous material
Thank You

Check out reformed materials online at http://www.colorado.edu/sei/departments/physics.htm

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