

A Research-Based Transformation of Purdue's Calculus-Based Physics Sequence: A 15 Year Journey

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Faculty Involved

- Prof. Lynn Bryan
- Prof. Erica Carlson
- Prof. Stephen Durbin
- Prof. Mark Haugan
- Prof. Andrew Hirsch
- Prof. Rebecca Lindell (Visiting)
- Prof. P. K. Imbrie (Engineering Education now at Texas A&M)

Students Involved

- Mr. David Blasing
- Dr. John Buncher
- Dr. Anna Douglas
- Mr. John Doyle
- Mr. Bernard Griggs
- Mr. Kyle Isch
- ENS. Max Kagan
- Mr. Jignesh Mehta
- Ms. Kelsie Niffenegger
- Dr. Eulsun Seung
- Mr. Matt Smith
- Mr. Ethan Stanley
- Mr. Jordon Steckloff
- Mr. Adam Szewciw
- Dr. Wendi Wampler
- Dr. Melissa Yale

Neil Armstrong
BS Aeronautical Engineering 1955

Overview of Transformation

- Calculus-based Physics Sequence, ca 1994
- Pre-Transformation, ca 1999
- Phase I Transformation – Implementation of Matter and Interactions Curriculum, 2001-2006
- Phase II Transformation
 - Semester I transformation, AY 2011 – AY2014
 - Semester II transformation AY 2013 – AY 2015

Purdue Calculus-based Physics Sequence ca 1994

- Purdue's Calculus-based Physics Sequence
 - Semester 1: Mechanics
 - Semester 2: Electricity and Magnetism
- Taught traditionally as a 5 hr course with the following per week
 - 2 1-hr lectures (1 faculty lecturer)
 - 2 1-hr recitation (1 Graduate TA)
 - 1 2-hr lab (1 Graduate TA)
- One semester Calculus prerequisite

Purdue Calculus-based Physics Sequence

Pre-Transformation ca 1999

- Still taught in same format as 1994
- Started incorporating University of Washington's Tutorials in Physics into the recitation sections of 1st Semester Mechanics
- Students worked together to solve Physics Education Research-based problems and activities

Purdue Calculus-based Physics Sequence Pre-Transformation ca 1999

- Under the direction of Department Head, Andy Hirsch, the Physics department examined the entire undergraduate program
- Interviewed current and past undergraduate students
- Results, Introductory Physics Sequence was BORING and repetitive.
- There had to be a better way!

Purdue Calculus-based Physics Sequence

Phase I Transformation AY 2001-2006

- In AY 2001, Department offered innovative Matter and Interactions Curriculum to Physics Majors
- Transformed course utilizing innovative Matter and Interactions Texts
- R. Chabay and B. Sherwood, *Matter and Interactions: Modern Mechanics 3rd Edition*, (Wiley, San Francisco, 2010).
- Faculty member Steve Durbin and Andy Hirsch worked with Freshman Engineering faculty to transform current physics sequence

Matter and Interactions: A Fundamental Shift

- Incorporates modern physics in its presentation of physics content
 - The atomic nature of matter with micro/ macro connections
- Unification of Physics based on atomic view of Matter
- Students learn how to computationally model physical phenomena

Modern Mechanics: Fundamental Principles

- Presents an alternative approach using only a few fundamental principles.
 - Momentum Principle
 - Energy Principle
 - Angular Momentum Principle

Purdue Calculus-based Physics Sequence

Phase I Transformation AY 2001-2006

- Additional requirements due to ABET accreditation of Purdue Engineering and Purdue's Registrar, the semester 1 course had to now be offered at only 4 hrs
 - Required Mechanics to reduce to 4 hrs
 - Electricity and Magnetism to remain at 4 hrs
- Created two new courses
 - Modern Mechanics (F2006)
 - E&M Interaction (S2006)

Purdue Calculus-based Physics Sequence

Phase I Transformation AY 2001-2006

- Purdue's Calculus-based Physics Sequence
 - Semester 1: Modern Mechanics
 - Semester 2: Electricity and Magnetism Interactions
- Taught traditionally as a 4 hr course with per week
 - 2 1-hr lectures (1 Faculty)
 - 1 1-hr recitation (1 GTA and 2 UTA)
 - 1 2-hr lab (1 GTA and 2 UTA)
- Calculus I is now a co-requisite

Purdue Calculus-based Physics Sequence

Phase I Transformation AY 2001-2006

- Instruction consists of
 - Lecture – 2 hrs weekly
 - Clicker Questions
 - Lab – 2 hrs weekly
 - Computational Modeling using VPython
 - Recitation -1 hr weekly
 - Cooperative Group problem solving
 - Informal Help Session
- Assessment consists of
 - In-class Clicker Questions
 - Online Homework - WebAssign
 - Course Exams

Need for further Transformation

- In 2010, Department Head, Nick Giordano asked faculty to review success of M&I implementation
- In Fall 2011, Prof. Andrew Hirsch brought visiting Prof. Rebecca Lindell in to help examine the success of the 1st semester course

Issues with Modern Mechanics ca 2011

- Difficulty with transfer of material covered throughout course to exams
 - Even when identical problems are given throughout
- UTA's and TA's do not have time to answer group questions since they are busy checking students off
- Recitation problems were no longer context rich problems, but couple of step textbook problems

Issues with Modern Mechanics ca 2011

- College students today are different than they were even ten years ago.
 - Constant multi-taskers
 - Sophisticated in their use of technology
- Students typically do not read the textbook prior to attending class
 - Cannot unpack the content
- Student scores on each of the online-homework, lab, recitation and clicker questions are approximately 90% compared with much lower exam scores.

Need for further Transformation

- In Spring 2012, we joined the 2nd cohort of Purdue's IMPACT scholars
- Instruction Matters: Purdue Academic Course Transformation (IMPACT) Initiative
- A University-wide program to help faculty and departments transform large lecture courses
 - More interactive and student centered
- Faculty work with redesign teams to transform their courses

Phase II Transformation Goals

Semester I: Modern Mechanics

- Adapting and/ or developing materials based on Physics Education Research for use at Purdue University.
- Transform the course that would be sustainable and would be easy to implement for future faculty assigned to the course.
- Transformation should be based on sound learning theory and practices.
- Transforming the course to be more interactive and integrated for students.
- Address the issues noted earlier

Modern Mechanics

Phase II Transformation AY 2012-AY2014

- Formalized use of cooperative group problem solving in Recitation. Focused on cooperative group problem solving.
- Restructured homework to better reflect problem-solving strategies
- Labs were restructured to include more computational modeling

Modern Mechanics Evaluation

Phase II Transformation AY 2012

- Student evaluations of the course via 34 Item survey asking students to evaluate different aspects course on enhancing their learning
- Pre-Post Test administration of Lawson's Classroom Test of Scientific Reasoning
- Primary trait analysis of student performance throughout the course.

Modern Mechanics Evaluation

Phase II Transformation AY 2013-2014

- Changes made after evaluation
- Continue to refine cooperative group recitation problems
- Introduced clicker-questions within recitation
- Labs currently under-revision
- No longer use Lawson Test, but focus on Primary Trait Analysis to evaluate success of instruction

Electricity & Magnetism Interactions

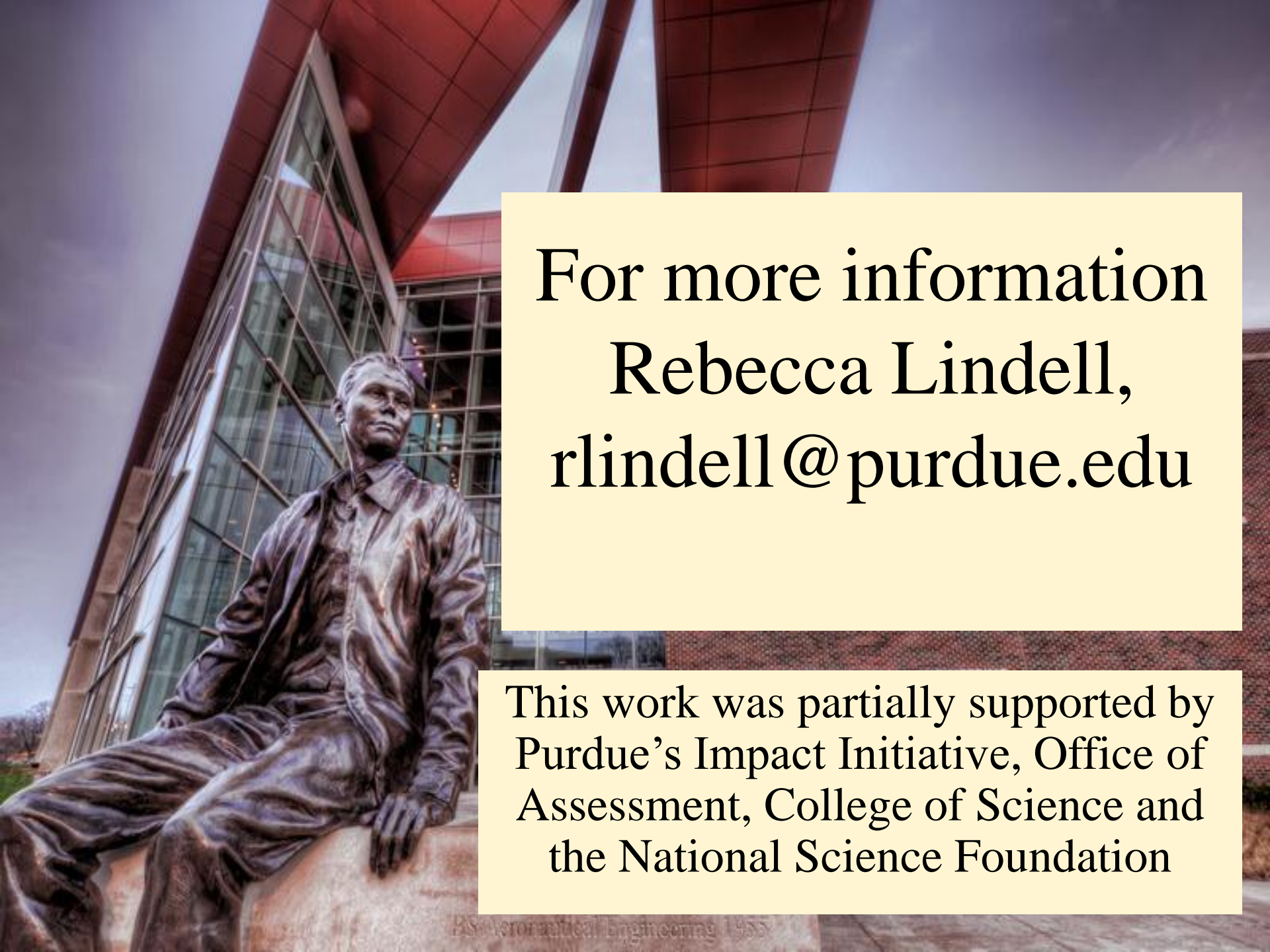
Phase II Transformation AY 2013-2015

- Mr. David Blasing introduced the use of pre-recitation conceptual clicker questions into Semester II recitations
- Conducted controlled study Spring 2014
- Student survey similar to one developed for semester 1 course
- Pre-Post Brief Electricity Magnetism Assessment
- Performance on exams

Electricity & Magnetism Interactions

Phase II Transformation AY 2013-2015

- Erica Carlson joined the Fall 2014 cohort of IMPACT
- Plans include video taping lectures and providing online
- Developing Haptic devices to assist students with understanding fundamental concepts in Electricity and Magnetism



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