Do students read textbooks?
E-text use in blended and online introductory physics courses

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Massachusetts Institute of Technology
Department of Physics and RLE
Dave Pritchard’s RELATE group @ MIT

Research in Learning, Assessing, and Tutoring Effectively

- Applying data mining techniques, learning analytics, and psychometrics to a variety of educational data sets.
- Content development (e-text, videos, and problems) and teaching (8.011 and Mechanics Online).

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Course/Learning management systems

• Large lecture introductory physics courses rely on CMS for homework and dissemination of course information

• LON-CAPA (www.loncapa.org)

• Mechanics Online: http://relate.mit.edu/physicscourse

- 14 Units covering introductory mechanics
- Over 1000 multilevel problems
- E-text and instructor videos centered around MAPS pedagogy
RELATE, data, and course management systems

- **LON-CAPA** has perhaps the largest content repository in the world: ~400,000 resources (nearly two decades of use)

- Learning management system at MSU for nearly **20 years**; spanning all subjects and all levels of university courses

- LON-CAPA used in both on-campus and online courses
  - 8.011 and IAP Mechanics ReView
  - Mechanics Online: [http://relate.mit.edu/physicscourse](http://relate.mit.edu/physicscourse)

- Currently migrating some of RELATE’s content to **edX** for on-campus (**8.01RQ**) courses, and “possibly” online courses

- Have been heavily involved with parsing **6.002x** server logs
Motivation: reading the book

- Can we leverage data accessible through course management systems to promote effective learning outcomes for students?
Motivation: *reading the book*

- Can we leverage data accessible through course management systems to promote effective learning outcomes for students?

... *Electronic Circuits*
MIT
- Agarwal, Lang
Sample of previous research on textbook use

- **“Perceived value of physics textbook”: Podolefsky, Finkelstein [1]**
  
  - 97% of students bought the book, less than half read regularly, and little to no correlation with course grade. Sample = 4 courses.

- **“Student textbook use in intro physics: Cummings, French, Cooney [2]**

  - Analyzed effectiveness of worked examples within the textbook and how course assignments affect reading. Found an initial link between course format and reading habits. Sample = 2 courses.

- Much of the textbook research has relied on student surveys and relatively small number of students, making it difficult to generalize results

- **Course management systems provide unprecedented access to large numbers of students and their interactions with course resources.**


Course structure affects students

- **Introductory Physics**: Laverty, Bauer, Kortemeyer, Westfall [1]
  - Frequent exams lead to gains in attitude and performance in introductory physics courses

- **Introductory Biology**: Haak, HilleRisLambers, Pitre, Freeman [2]
  - Highly structured weekly activities lead to gains in performance and reduced the achievement gap in introductory biology courses

- Course structure affects attitudes and performance
  - frequent exams, embedded assessment, peer grading, etc...


Motivation: Do students read the e-text?

- As authors and instructors we aim to better understand how students utilize our e-text, as well as the utility of our e-text.
- Lack a framework with which to compare our small courses?
- How does course structure affect student behavior and learning?
Motivation: Do students read the e-text?

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• As authors and instructors we aim to better understand how students utilize our e-text, as well as the utility of our e-text

• Lack a framework with which to compare our small courses?

• How does course structure affect student behavior and learning?

Disclaimer: this is only a discussion of behavior... for now!
Outline

• Introduction
  - RELATE, previous research, course structure

• Courses/Data

• Methodology
  - Sever logs, activity and overall usage, time spent

• Examining e-text use in blended courses
  - Samples from MSU and MIT
  - Course structure affects student behavior

• Examining e-text use in online courses
  - Samples from MSU, MIT, and edX
  - Does the blended course framework fit with online courses?

• Conclusions and future work
General description of courses
General description of courses

Mechanics Reform
MIT
- RELATE

- Reform course using best practices for teaching and content development

- N ~ 40 per course

- Course components:
  - Homework
  - e-text
  - Discussion
  - Some videos
  - Weekly quizzes

Tuesday, November 20, 2012
General description of courses

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**Multimedia Physics**
Michigan State University  
- Bauer, Benenson, Westfall

- Sample of nearly a decade of large lecture introductory physics courses
- N ~ 150 per course
- Course components:
  - Homework
  - e-text
  - Discussion
  - Some videos
  - Scantron exams

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General description of courses

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  - Discussion
  - Some videos
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### Electronic Circuits
- **MIT**
- **Agarwal, Lang**

- Pilot course for edX, introductory level and open to anyone in the world
- N ~ 10,000 per course
- Course components:
  - Homework
  - Laboratory
  - Lecture Videos/Exercises
  - Discussion
  - e-text
  - Wiki
  - Exams
e-texts associated with these courses

**Mechanics Reform**  
MIT  
- RELATE

**Multimedia Physics**  
Michigan State University  
- Bauer, Benenson, Westfall

**... Electronic Circuits**  
MIT  
- Agarwal, Lang

Why study physics?

Map study your answer to this question as: “Because it is required for my major!” While this is certainly a worthy motivation, will it last to fuel on it another addictive habit?

Physics is the science on which all other sciences and engineering sciences are built. Most of our technological advances, from future robots to telescopes, from computers to refrigerators, from cars to appliances, have been built on basic physics. A good grasp of the physics concepts and language needed for the modern workplace is still an important and relevant topic.

Physics is intimately connected with mathematics, and it brings the abstract concepts of math, such as functions and integrals, to life. Analytical thinking and general problem-solving techniques that are developed in physics are practical tools and will remain useful for the rest of your life.

Physics, and in particular physics, is a way to remove fundamental from our models and explanations for the world around us. Precise thinking was found to be necessary to explain natural phenomena. For example, Einstein's General Theory of Relativity is based on the idea that gravity is not a force but the curvature of space-time. The General Theory of Relativity was developed by Albert Einstein nearly a century ago, and it has been confirmed by many experiments. This theory has not only revolutionized our understanding of the universe but also our view of the world around us.

Map study physics is a course that introduces students to the fundamental concepts of physics. This course is designed to help students develop the skills and knowledge necessary to understand and analyze the physical world.

- MAPS pedagogy
- Designed for a reform course, students with prior experience
- Traditional structure put into online format with best practices
- Authors have ability to vary content
- Introductory text for circuits and electronics
- Image conversion of physical textbook
Measuring student-resource interactions

- Log Parsing and Exploratory Data Mining
  - Activity logs contain time-stamped student interactions (**clicks**)
  - LON-CAPA and edX both provide activity logs

- What aspects of e-text use can we measure by parsing activity logs?
  - Overall frequency of accesses
  - Number of unique accesses
  - Total time spent
Measuring student-resource interactions

- Log Parsing and Exploratory Data Mining
  - Activity logs contain time-stamped student interactions (*clicks*)
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Extracting information from these logs is a topic worthy of it’s own seminar!!!

- What aspects of e-text use can we measure by parsing activity logs?
  - Overall frequency of accesses
  - Number of unique accesses
  - Total time spent
Methodology: First course analyzed

**Combination of three sections of the same large lecture introductory physics course**

**University wide enrollment**

**Personal note:**

- Thrilled to have such a large population of students!
- But didn’t really know what to expect...

<table>
<thead>
<tr>
<th>MSU Courses</th>
<th>Students</th>
<th>e-text</th>
<th>Exams</th>
<th>e-text assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro Physics</td>
<td>898</td>
<td>Secondary</td>
<td>3 + final</td>
<td>No</td>
</tr>
</tbody>
</table>

**Multimedia Physics**

Michigan State University

- Bauer, Benenson, Westfall

**Why study physics?**

- What does your answer to this question tell you? Because it is required for my major? While this is certainly a worthy motivation, it is not the only reason to take an introductory physics course. Physics is the science on which all other sciences and engineering sciences are built. Most of our technological advances, from the computers we use each day to the cars we drive, are based on our understanding of physical principles.

- Intro Physics is connected with the science of mathematics, and it brings the abstract concepts of math, such as the concepts used in engineering or physics as a whole, to life. It allows people to understand concepts that are otherwise difficult to grasp. Physics is also connected with the science of science, and it is through our understanding of physics that we have come to understand the world around us.

- Physics is important because it helps us understand the way the world works. It is through physics that we have developed technology that changes the way we live our lives. Physics is also important because it helps us understand the history of our planet. The study of physics involves using models and simulations of the way the world works. These models and simulations help us understand how the world has evolved over time.

- Physics is important because it helps us understand the nature of the universe. The universe is vast and complex, and physics helps us understand the fundamental laws that govern it. Physics is also important because it helps us understand the nature of matter. Matter is made up of tiny particles, and physics helps us understand how these particles interact with each other.

- Physics is important because it helps us understand the nature of energy. Energy is a fundamental concept in physics, and it is through physics that we have developed technology that allows us to harness and use energy to change the way we live our lives.

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e-text activity per day: Overall frequency

MSU: large lecture introductory physics course

Page views per student – A(t)/N

N = 904

Sep Oct Nov Dec

t (Semester Days)
e-text activity per day: Overall frequency

MSU: large lecture introductory physics course

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Exams

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MSU: large lecture introductory physics course

Page views per student – A(t)/N

N= 904

Exams

t (Semester Days)
e-text activity per day: *Overall frequency*

MSU: large lecture introductory physics course

N = 904

Page views per student – $A(t)/N$

$0 \leq A(t)/N \leq 5$

Decreasing activity after first exam

**Exams**

$t$ (Semester Days)

Sep Oct Nov Dec
Unique e-text pages viewed: *ccdf distribution*

- Incredibly low usage
- Time spent < 1hr
- Raw time data not shown

- Although not very inspiring, this was a great place to start!
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MSU: large lecture introductory physics course

13% of students read > 13% of the e-text
Outline

• Introduction
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• Examining e-text use in blended courses
  - Samples from MSU and MIT
  - Course structure affects student behavior

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• Conclusions and future work
Blended courses at MSU and MIT

- **MSU e-text** - Mulit-Media Physics e-text (traditional sequence)
  - Use almost a decade of introductory physics courses to build a framework for understanding e-text usage

- **MIT e-text** - @RELATE’s ILEM e-text (MAPS pedagogy)
  - Not enough students to make general claims about e-text usage

- **Course Structure:**
  - assignment of e-text, exam frequency, embedded assessment
## Course structure categorization

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<thead>
<tr>
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<th>Students</th>
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<tbody>
<tr>
<td>Supplementary A</td>
<td>898</td>
<td>Secondary</td>
<td>3 + final</td>
<td>No</td>
</tr>
<tr>
<td>Supplementary B</td>
<td>911</td>
<td>Secondary</td>
<td>3 + final</td>
<td>No</td>
</tr>
<tr>
<td>Supplementary C</td>
<td>808</td>
<td>Secondary</td>
<td>2 + final</td>
<td>No</td>
</tr>
<tr>
<td>Traditional A</td>
<td>159</td>
<td>Primary</td>
<td>2 + final</td>
<td>No</td>
</tr>
<tr>
<td>Traditional B</td>
<td>190</td>
<td>Primary</td>
<td>2 + final</td>
<td>No</td>
</tr>
<tr>
<td>Reformed A</td>
<td>211</td>
<td>Primary</td>
<td>6 + final</td>
<td>Yes</td>
</tr>
<tr>
<td>Reformed B</td>
<td>209</td>
<td>Primary</td>
<td>6 + final</td>
<td>Yes</td>
</tr>
<tr>
<td>Reformed C</td>
<td>197</td>
<td>Primary</td>
<td>6 + final</td>
<td>Yes</td>
</tr>
<tr>
<td>Reformed D</td>
<td>254</td>
<td>Primary</td>
<td>6 + final</td>
<td>Yes</td>
</tr>
<tr>
<td>MIT Reformed</td>
<td>37</td>
<td>Primary</td>
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<td>211</td>
<td>Primary</td>
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</table>
**Blended courses: e-text activity per day**

- **Supplementary A**
  - N = 909

- **Traditional A**
  - N = 158

- **Reformed A**
  - N = 210

- Large spikes indicate exams
- Weekly activity after first exam decreases in Supplementary and Traditional courses
General usage: *percentage of e-text viewed*

- Categories span usage cases
- Reformed courses have greatest percentage of e-text viewed
Time spent viewing the *identical* e-text

**Traditional A**

- \( T = 6.223 \) hrs

**Traditional B**

- \( T = 9.129 \) hrs

**Reformed A**

- \( T = 12.6 \) hrs

**Reformed B**

- \( T = 13.61 \) hrs

**Reformed C**

- \( T = 10.12 \) hrs

**Reformed D**

- \( T = 12.14 \) hrs
Mean time spent viewing the *identical* e-text

- These data are quite noisy
- Simply want to identify the most general of trends
Median time each page: Trad. A vs Reform. A

slope from fit = 1.02, Std. Error = 0.02
Total e-text views/student: Trad.A vs Reform.A

slope from fit = 1.68, Std. Error = 0.05
Summary: Blended courses from MSU and MIT

- Course structure affects e-text use
  - Larger percentage of the e-text is accessed
  - Frequent exams and embedded assessment lead to more interactions with the e-text

- Students are spending more time “reviewing” the e-text in the reformed courses
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• Conclusions and future work
Online courses from MSU, MIT, and edX

- Do the e-text features seen in blended courses generalize to online courses?

- **MSU Courses**
  - Distance education online courses
  - Five years worth of summer online courses; same format as previously discussed blended introductory physics courses

- **MIT Mechanics**
  - @RELATE’s ILEM e-text (MAPS pedagogy)
  - Mechanics Online: reform course offered free to anyone in the world (spring and summer 2012)

- edX: 6.002x
  - Circuits and Electronics
  - Inaugural course for edX (spring 2012)
## Classification by course structure

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</tr>
</thead>
<tbody>
<tr>
<td>Traditional A</td>
<td>155</td>
<td>Primary (344)</td>
<td>4 + final</td>
<td>No</td>
</tr>
<tr>
<td>Traditional B</td>
<td>231</td>
<td>Primary (344)</td>
<td>4 + final</td>
<td>No</td>
</tr>
<tr>
<td>Traditional C</td>
<td>165</td>
<td>Primary (341)</td>
<td>3 + final</td>
<td>No</td>
</tr>
<tr>
<td>Traditional D</td>
<td>187</td>
<td>Primary (343)</td>
<td>3 + final</td>
<td>No</td>
</tr>
<tr>
<td>Traditional E</td>
<td>163</td>
<td>Primary (481)</td>
<td>3 + final</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MIT Courses</th>
<th>Active Students</th>
<th>e-text</th>
<th>Exams</th>
<th>e-text assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mech Online A</td>
<td>~ 70</td>
<td>Primary (281)</td>
<td>10 quizzes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mech Online B</td>
<td>~ 100</td>
<td>Primary (323)</td>
<td>10 quizzes</td>
<td>Yes</td>
</tr>
<tr>
<td>6.002x</td>
<td>~ 7000</td>
<td>Secondary (1009)</td>
<td>1 + final</td>
<td>No</td>
</tr>
</tbody>
</table>
Online courses: e-text activity per day

- Again, large spikes indicate exams
- Again, weekly activity after first exam decreases in Traditional and 6.002x
- Online courses require better filters for active students!
Online Courses: Semester e-text activity

- MSU distance learning online courses behave similarly to their on-campus courses.
- MIT reformed course also behaves similar to other reform courses.
- edX similar to a course implementing a supplementary text.
Summary: Online courses MSU, MIT, and edX

- **What about time?** Actively investigating ways of comparing time spent on “very different” e-texts

- Course structure affects e-text use

- Patterns point toward more review, but need more data for repeated courses

- Exploring more data options from LON-CAPA and MSU
Conclusions and Future Work

- Course structure affects student behavior
- Students still view more of the e-text in a “reform” structured course
- Blended and Online courses both fit within our proposed framework
- Optimizing Learning:
  - Add performance metrics that will allow us to analyze which course structure and associated resources maximize student learning
Current... Future work

- Our analysis and framework seem to be extending to resource usage in 6.002x
- Multitude of high quality resources that should highlight student’s choice of learning resources

- N ~ 10,000 per course
- Course components:
  - Homework
  - Laboratory
  - Lecture Videos/Exercises
  - Discussion
  - e-text
  - Wiki
  - Exams
Future: Time spent on course components

- 6.002x: Different data set, but provides many more resources to track

6.002x: inaugural course for edX

Assessment–based course component activity per day

Learning based course component activity per day

N = 7159 midterm and final examinees

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Future: Time spent on course components

- 6.002x: Different data set, but provides many more resources to track

6.002x: inaugural course for edX

N = 7159 midterm and final examinees

Percentage of time spent on course components

- Lecture.Video 31%
- Homework 21%
- Discussion 16%
- Lab 11%
- Lecture.Problem 12%
- Tutorial 2%
- Book 5%
- wiki 1%

Unique resource usage by course component

- N = 7159
- midpoint and final examinees

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Thank you for your time!

References


