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

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edX

M A P S

RELATE @ MIT

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Dave Pritchard's RELATE group @ MIT

Research in **L**earning, **A**ssessing, and **T**utoring **E**ffectively

- 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).

Mass. Institute of Tech.
David E. Pritchard
Analia Barrantes
Yoav Bergner
Colin Fredericks
Zach Pardos
Saif Rayyan
Daniel Seaton

George Washington Univ.
Raluca Teodorescu

MSU / Sabbatical at MIT
Gerd Kortemeyer

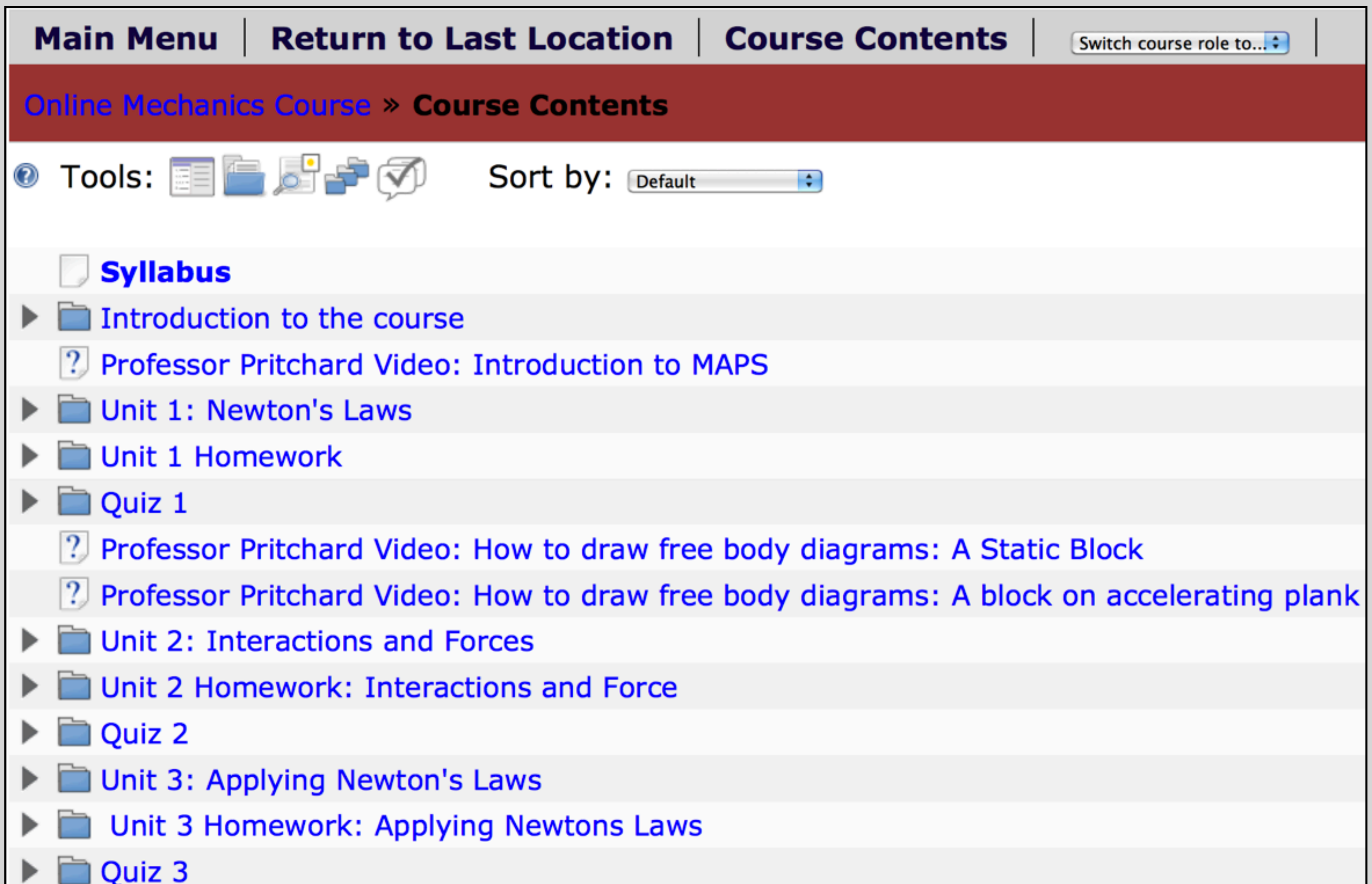
Visitor / Ostfalia (DE)
Stefan Dröschler

Brown University
Carie Cardamone

University of Wisc. - Plattville
Andrew Pawl

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

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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

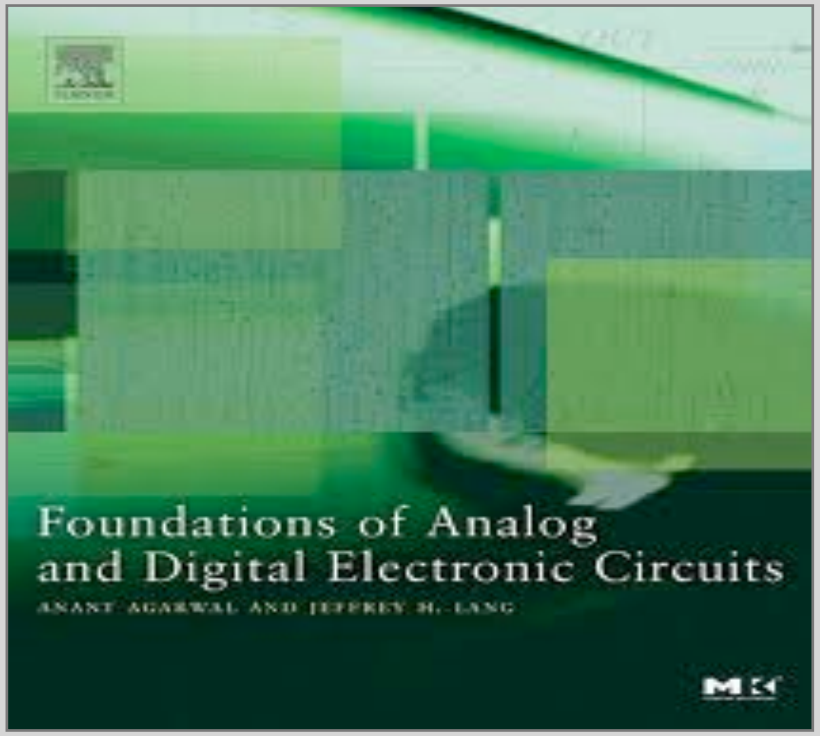
- LON-CAPA used in both on-campus and online courses
  - 8.011 and IAP Mechanics ReView
  - Mechanics Online: http://relate.mit.edu/physicscourse

- 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?

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



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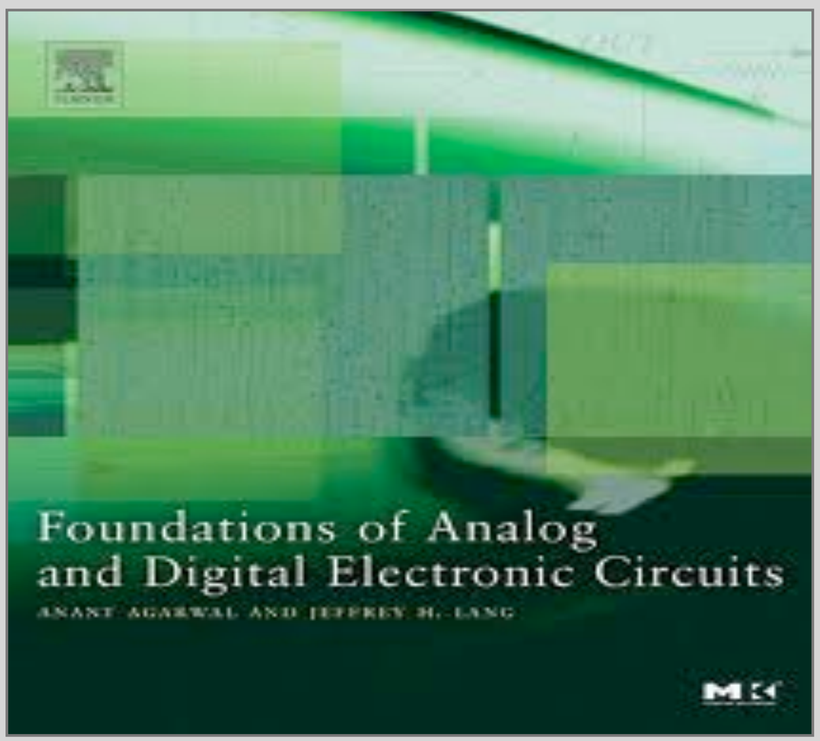
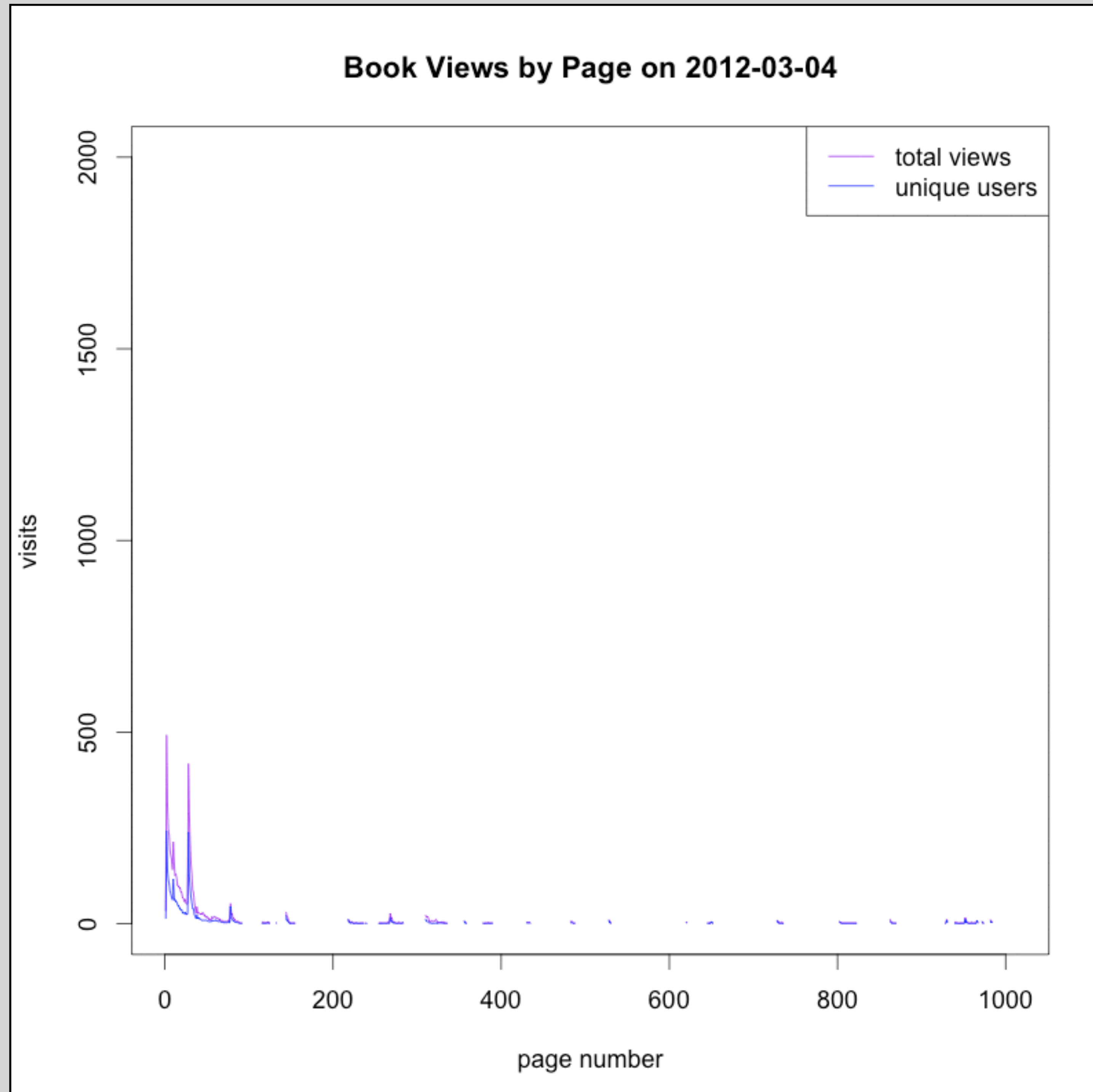




Sample of previous research on textbook use

- "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.*

[1] - "The Perceived Value of College Physics Textbooks", The Physics Teacher, (accepted).

[2] - "Student Textbook Use in Introductory Physics", Proceedings of Physics Education Research Conference (2002)

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

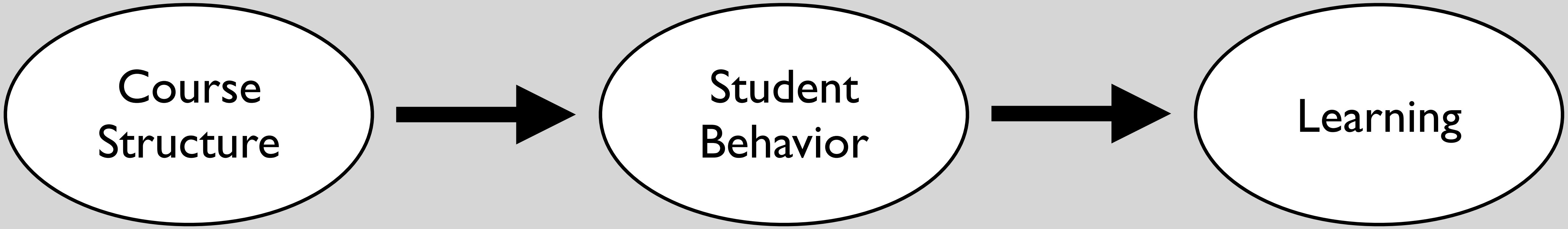
- Course structure affects attitudes and performance
  - frequent exams, embedded assessment, peer grading, etc...

[1] - "Want to Reduce Guessing and Cheating While Making Students Happier? Give More Exams!", *The Physics Teacher*, (accepted).

[2] - "Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology", *Science*, Vol. **332,** 1213 (2011)

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?



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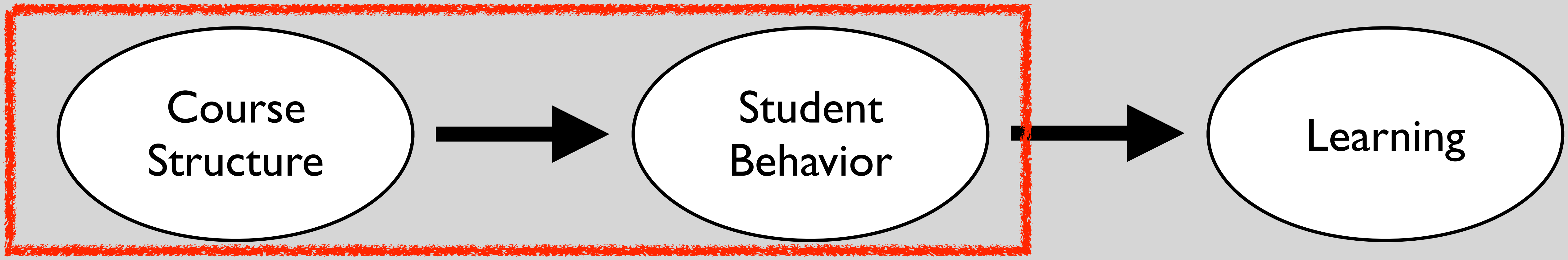

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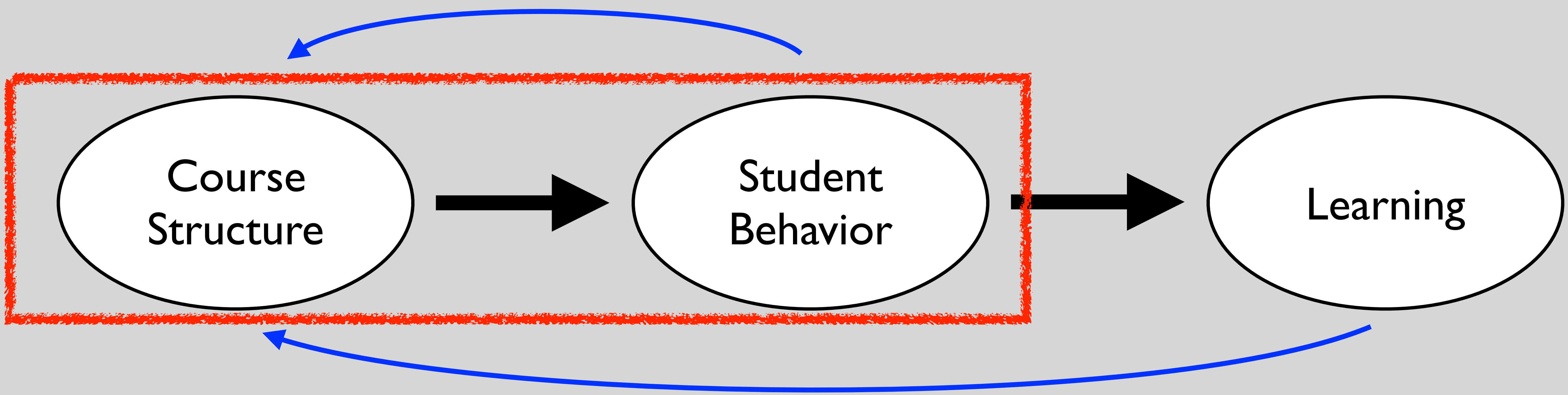

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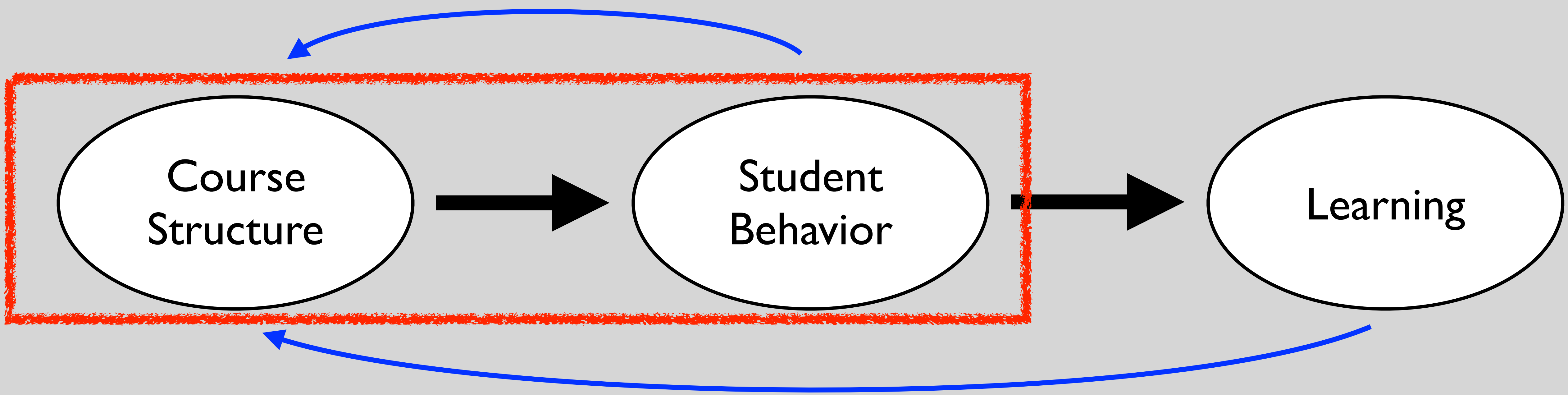

Disclaimer: this is only a discussion of behavior... for now!

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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

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General description of courses

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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

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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
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  - Discussion
  - Some videos
  - Scantron exams

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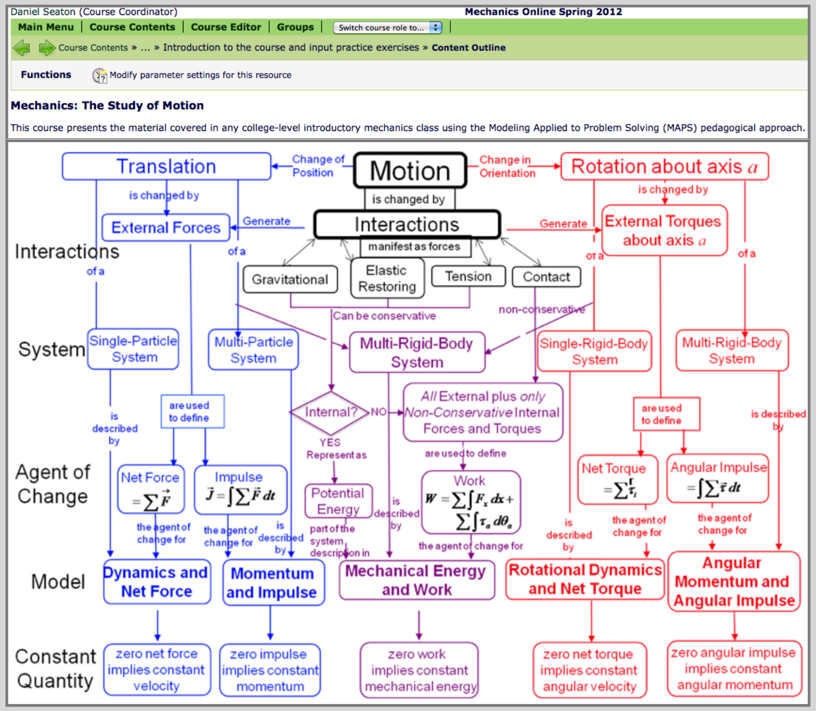
... Electronic Circuits
MIT
- *Agarwal, Lang*

- 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*



- MAPS pedagogy
- Designed for a reform course, students with prior experience

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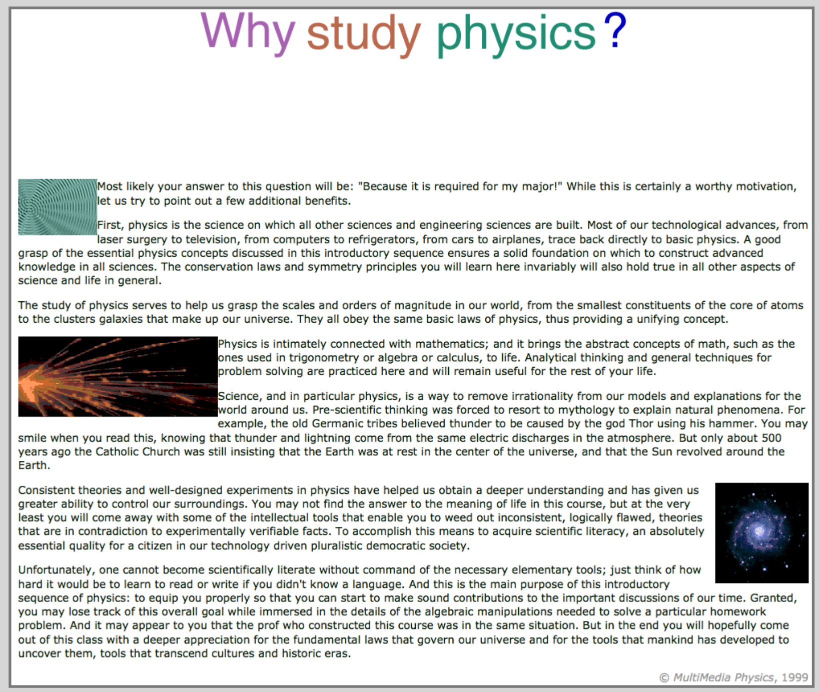
Why study physics?

Most likely your answer to this question will be: "Because it is required for my major!" While this is certainly a worthy motivation, let us try to point out a few additional benefits.

First, physics is the science on which all other sciences and engineering sciences are built. Most of our technological advances, from laser surgery to television, from computers to refrigerators, from cars to airplanes, trace back directly to basic physics. A good grasp of the essential physics concepts discussed in this introductory sequence ensures a solid foundation on which to construct advanced knowledge in all sciences. The conservation laws and symmetry principles you will learn here invariably will also hold true in all other aspects of science and life in general.

The study of physics serves to help us grasp the scales and orders of magnitude in our world, from the smallest constituents of the core of atoms to the clusters galaxies that make up our universe. They all obey the same basic laws of physics, thus providing a unifying concept.

Physics is intimately connected with mathematics; and it brings the abstract concepts of math, such as the ones used in trigonometry or algebra or calculus, to life. Analytical thinking and general techniques for problem solving are practiced here and will remain useful for the rest of your life.

Science, and in particular physics, is a way to remove irrationality from our models and explanations for the world around us. Pre-scientific thinking was forced to resort to mythology to explain natural phenomena. For example, the old Germanic tribes believed thunder to be caused by the god Thor using his hammer. You may smile when you read this, knowing that thunder and lightning come from the same electric discharges in the atmosphere. But only about 500 years ago the Catholic Church was still insisting that the Earth was at rest in the center of the universe, and that the Sun revolved around the Earth.

Consistent theories and well-designed experiments in physics have helped us obtain a deeper understanding and has given us greater ability to control our surroundings. You may not find the answer to the meaning of life in this course, but at the very least you will come away with some of the intellectual tools that enable you to weed out inconsistent, logically flawed, theories that are in contradiction to experimentally verifiable facts. To accomplish this means to acquire scientific literacy, an absolutely essential quality for a citizen in our technology driven pluralistic democratic society.

Unfortunately, one cannot become scientifically literate without command of the necessary elementary tools; just think of how hard it would be to learn to read or write if you didn't know a language. And this is the main purpose of this introductory sequence of physics: to equip you properly so that you can start to make sound contributions to the important discussions of our time. Granted, you may lose track of this overall goal while immersed in the details of the algebraic manipulations needed to solve a particular homework problem. And it may appear to you that the prof who constructed this course was in the same situation. But in the end you will hopefully come out of this class with a deeper appreciation for the fundamental laws that govern our universe and for the tools that mankind has developed to uncover them, tools that transcend cultures and historic eras.

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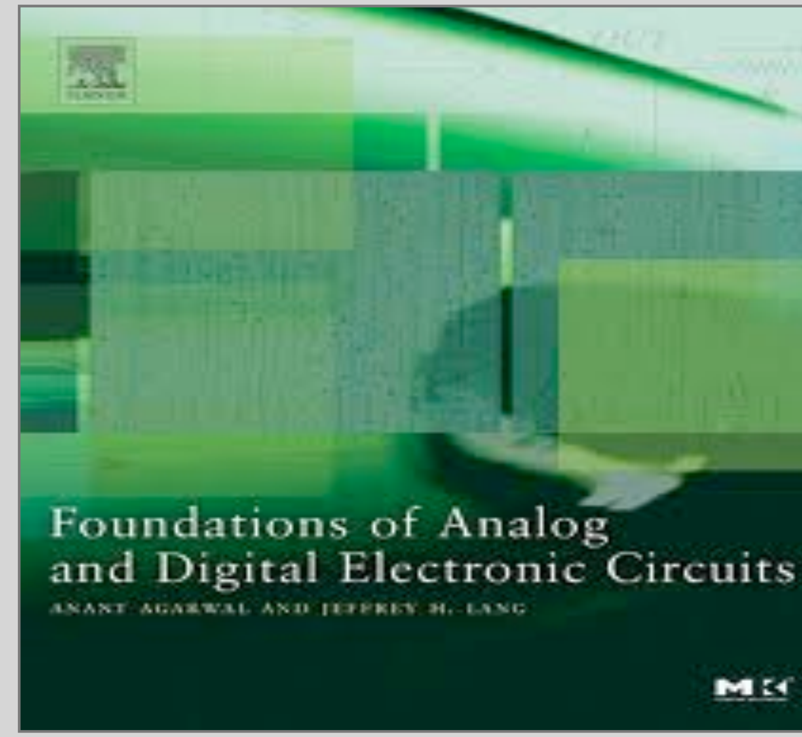
- Traditional structure put into online format with best practices
- Authors have ability to vary content

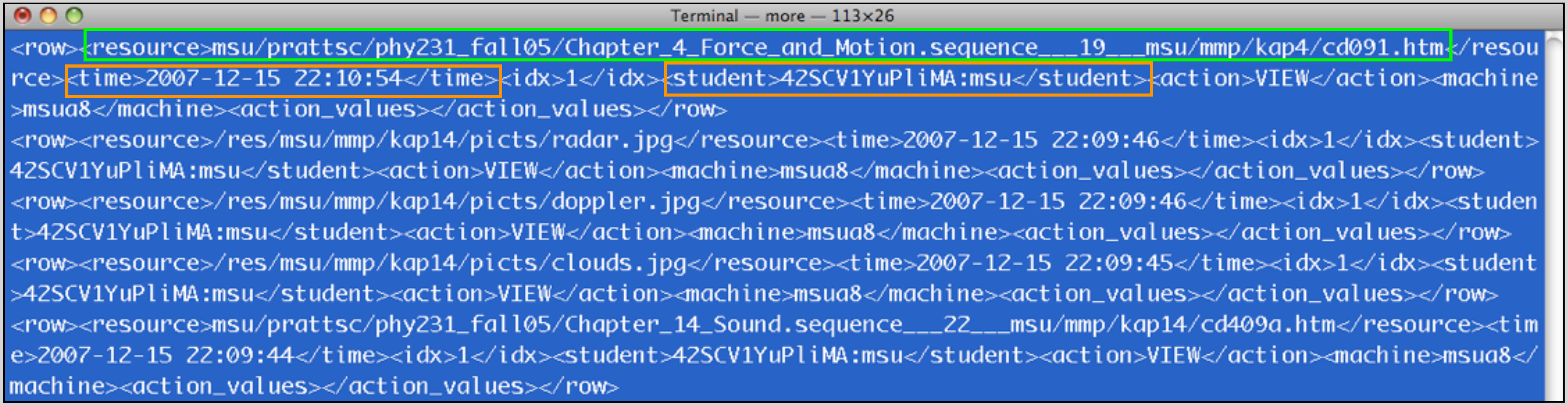
... Electronic Circuits
MIT
- *Agarwal, Lang*



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

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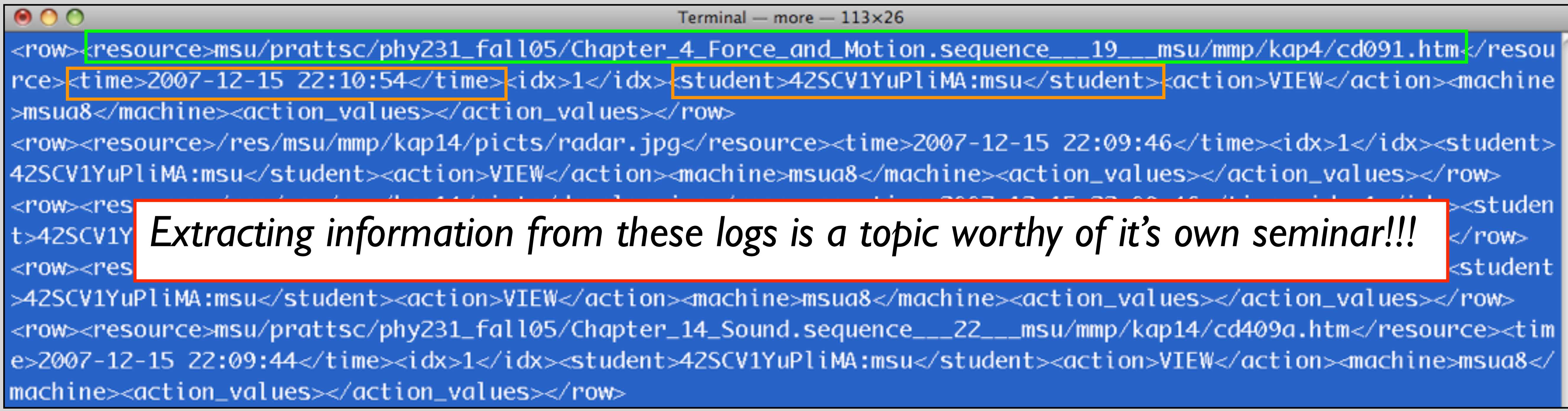

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Methodology: *First course analyzed*

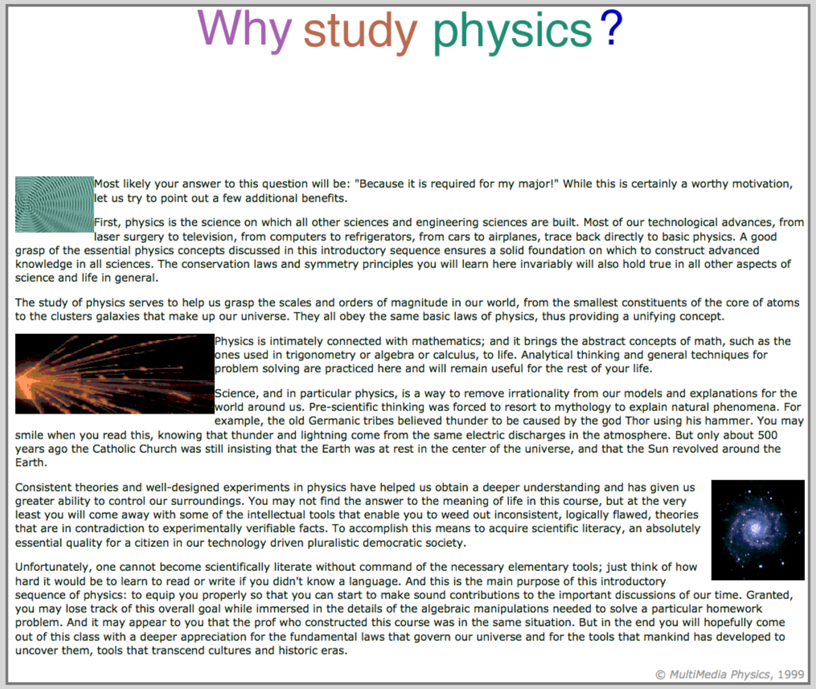
MSU Courses	Students	e-text	Exams	e-text assessment
Intro Physics	898	Secondary	3 + final	No

- 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...

Multimedia Physics
Michigan State University
- Bauer, Benenson, Westfall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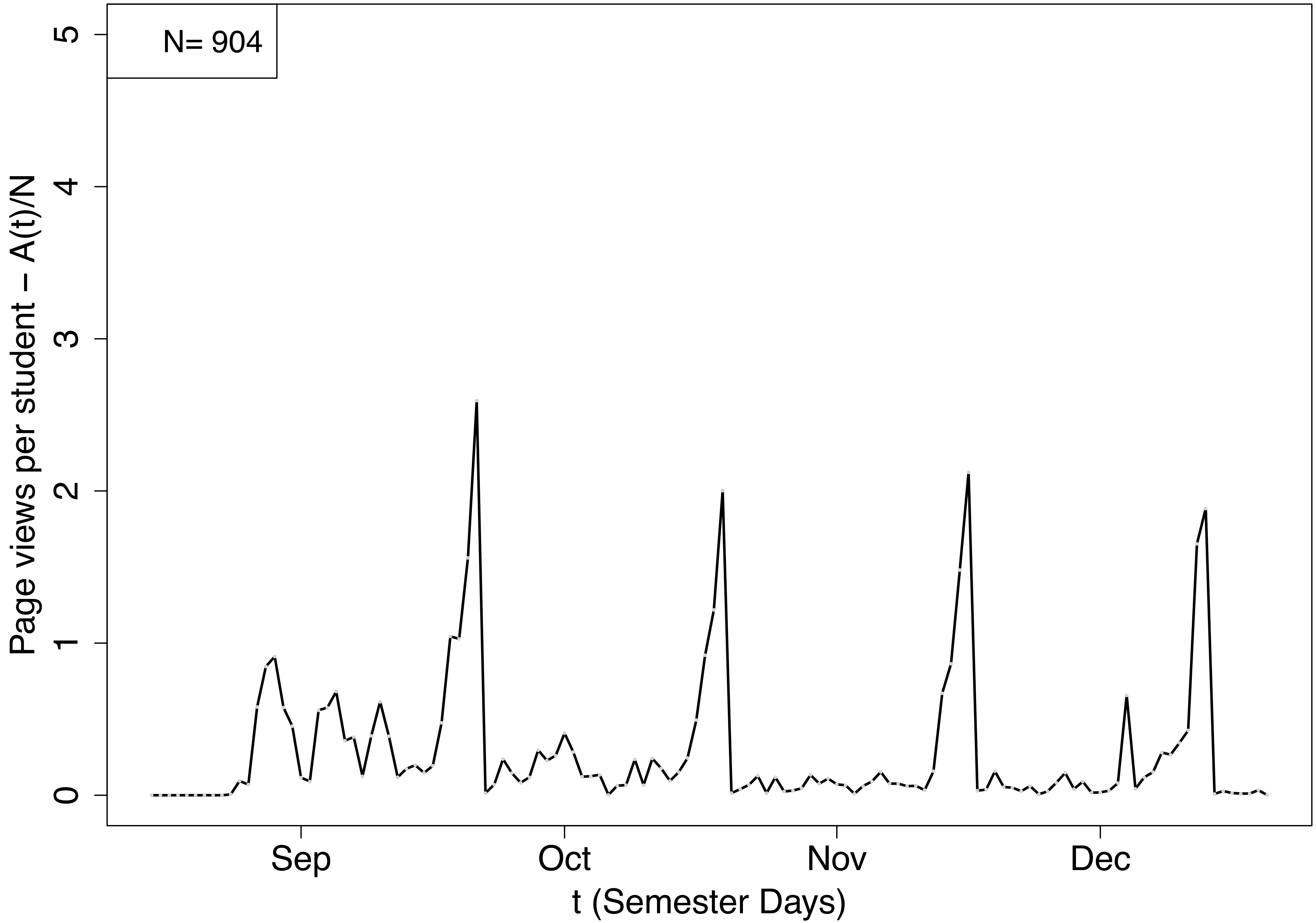
e-text activity per day: *Overall frequency*

MSU: large lecture introductory physics course



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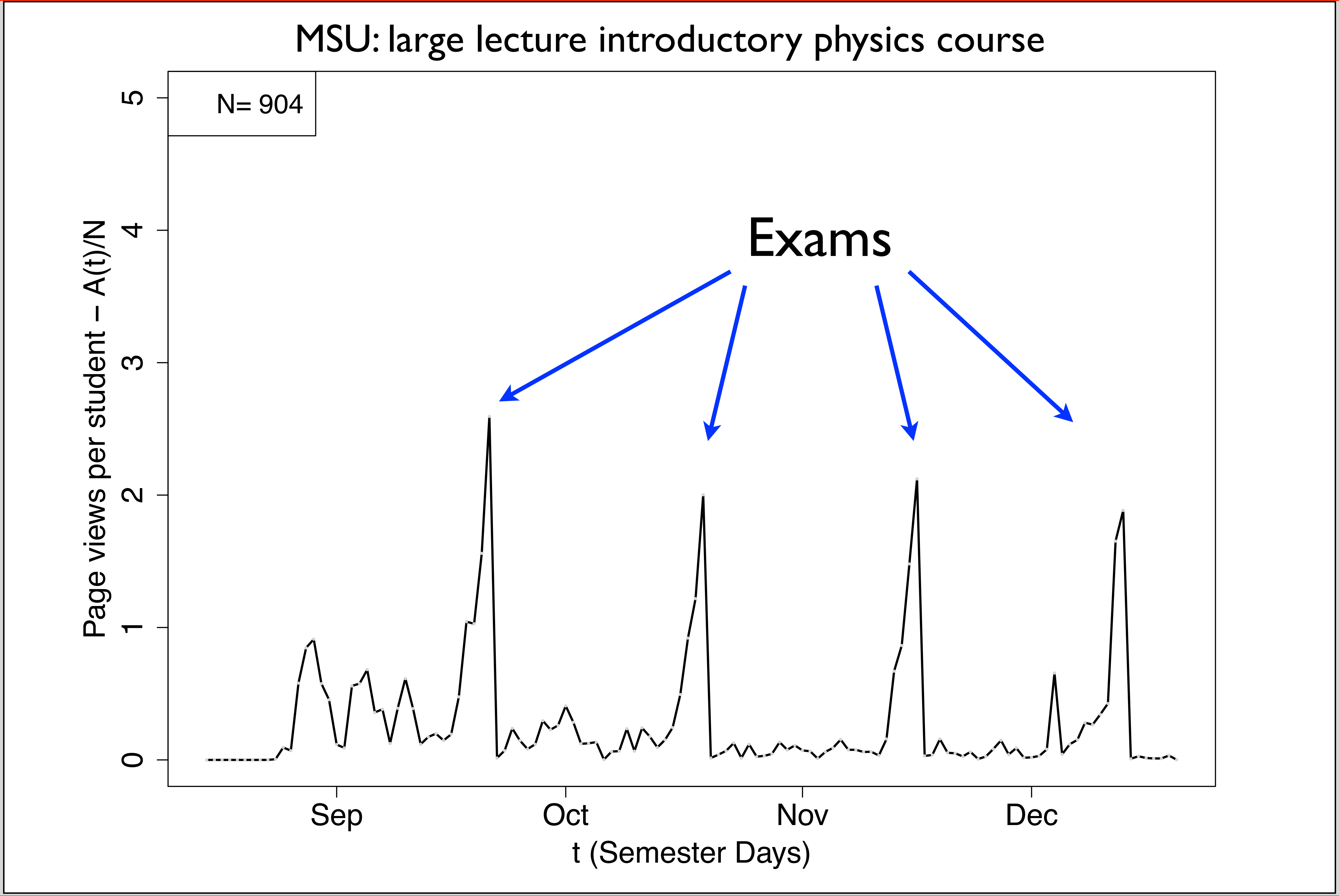

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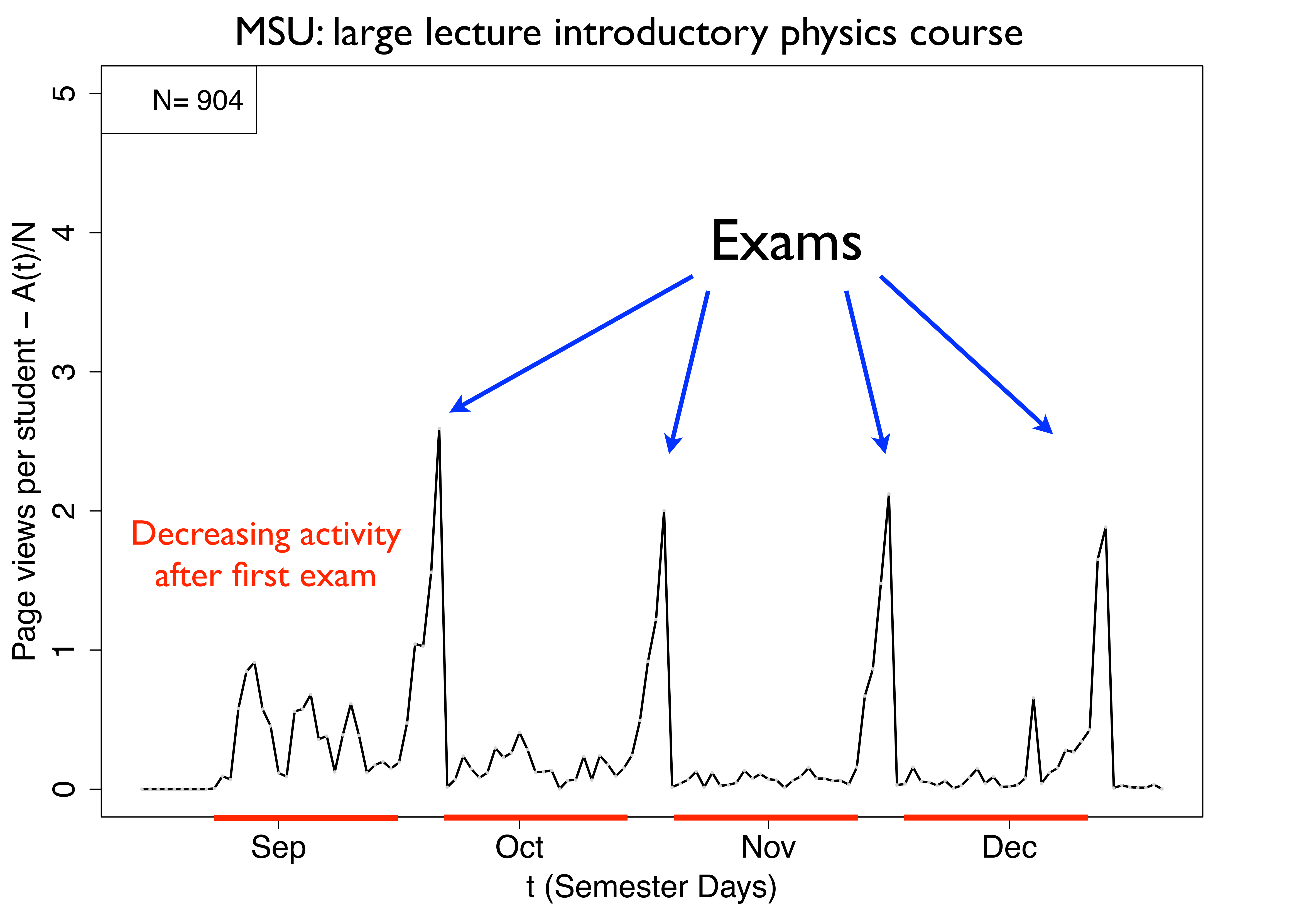
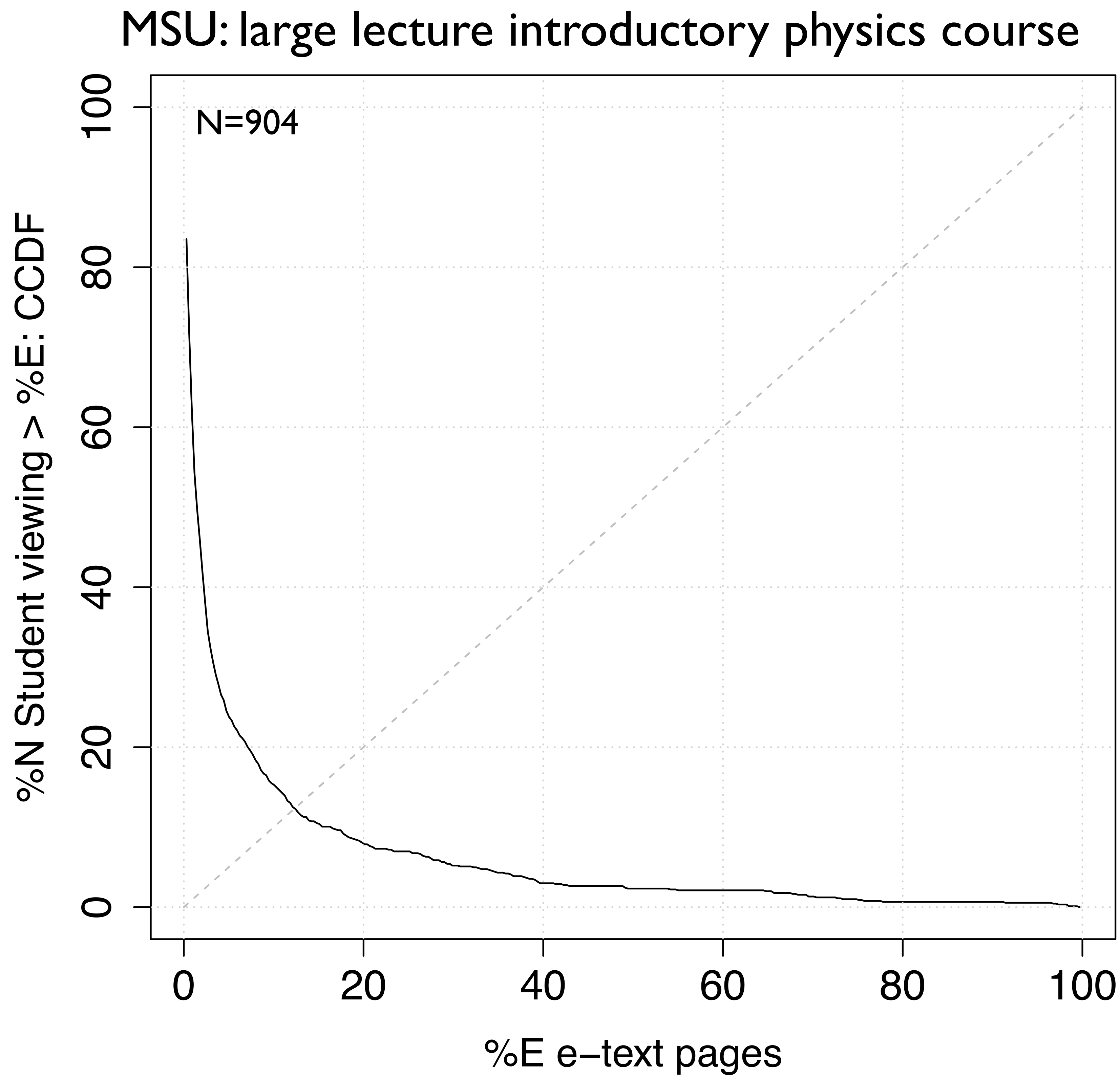


Unique e-text pages viewed: *ccdf distribution*

- 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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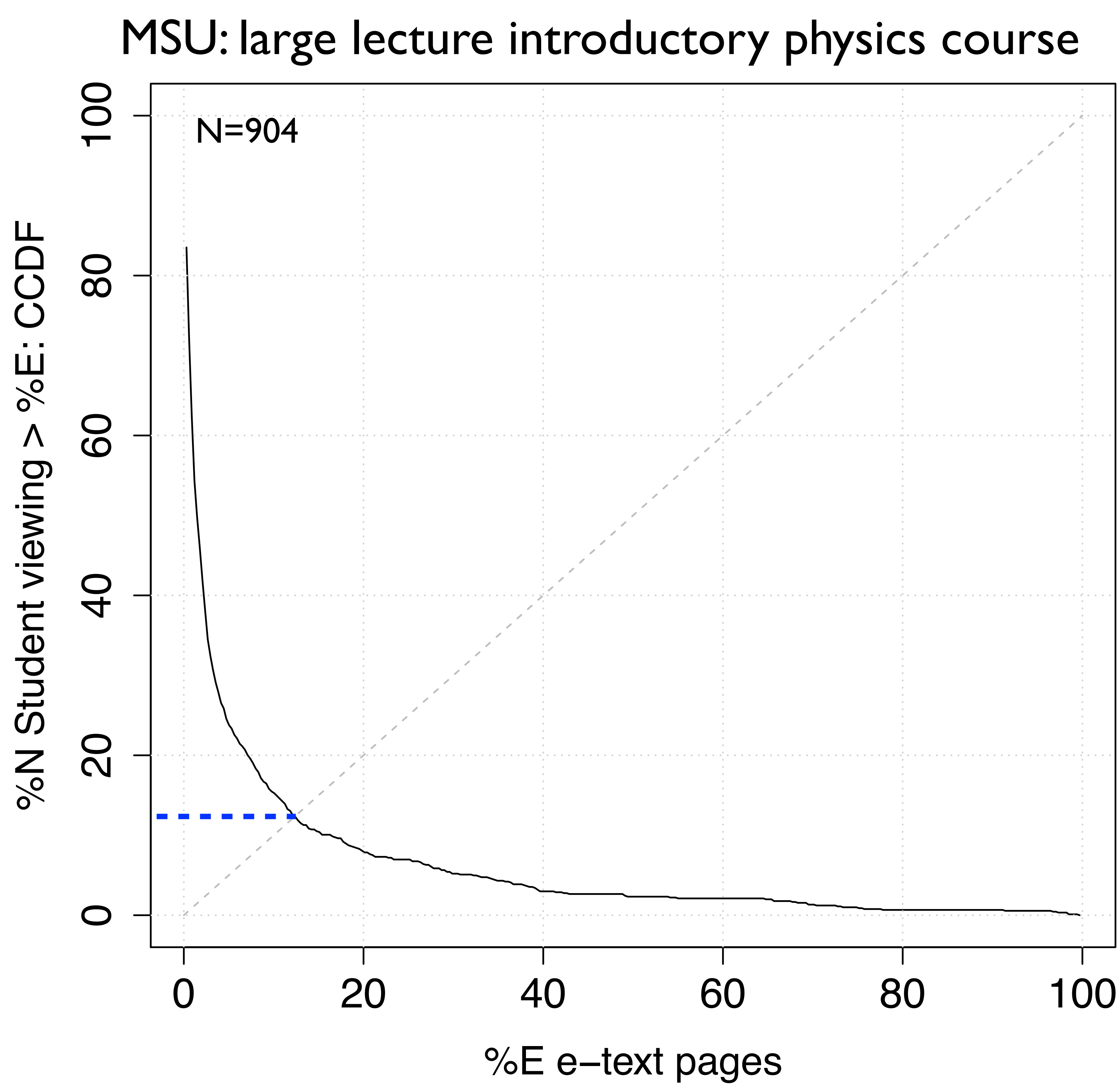

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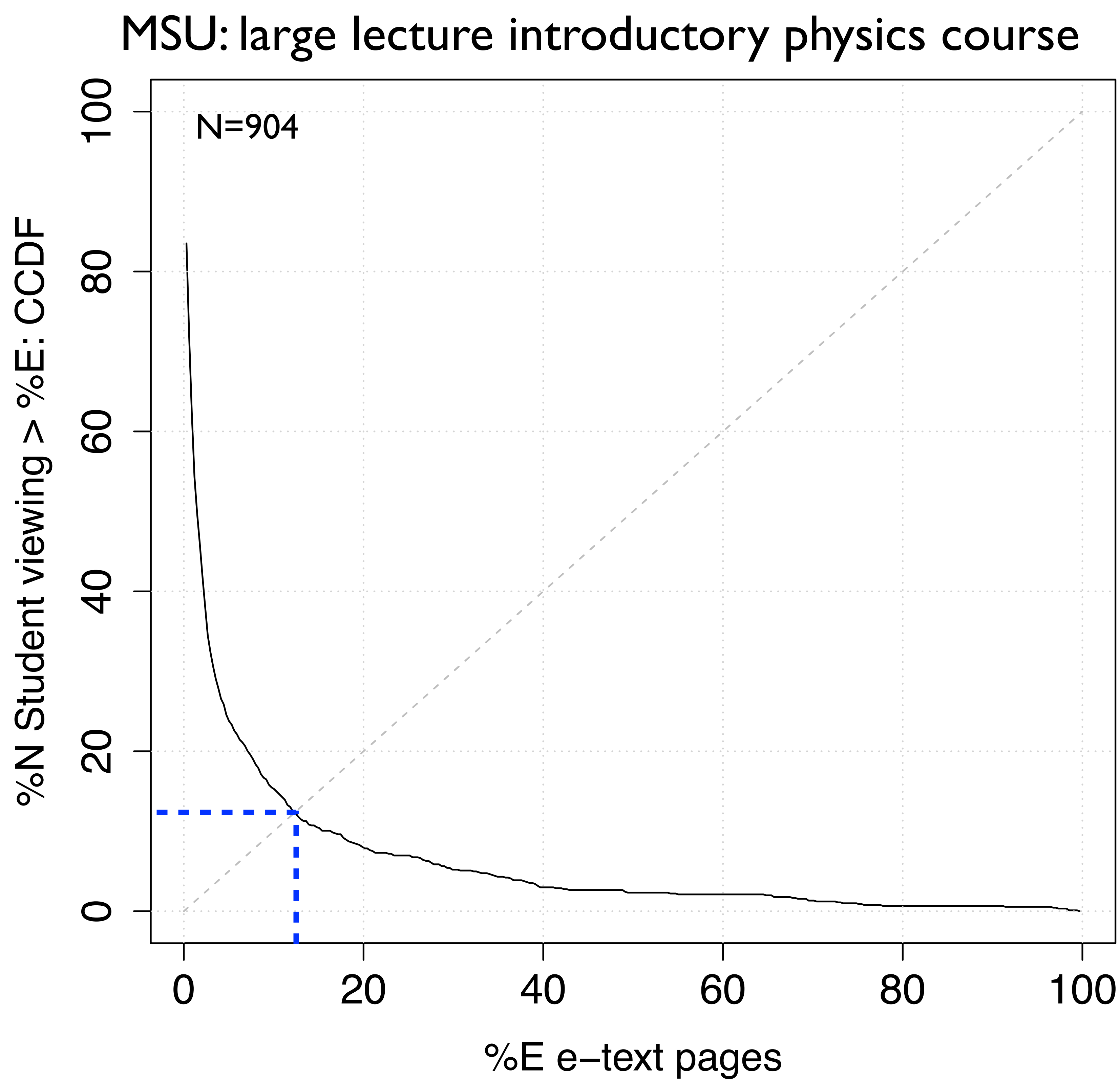

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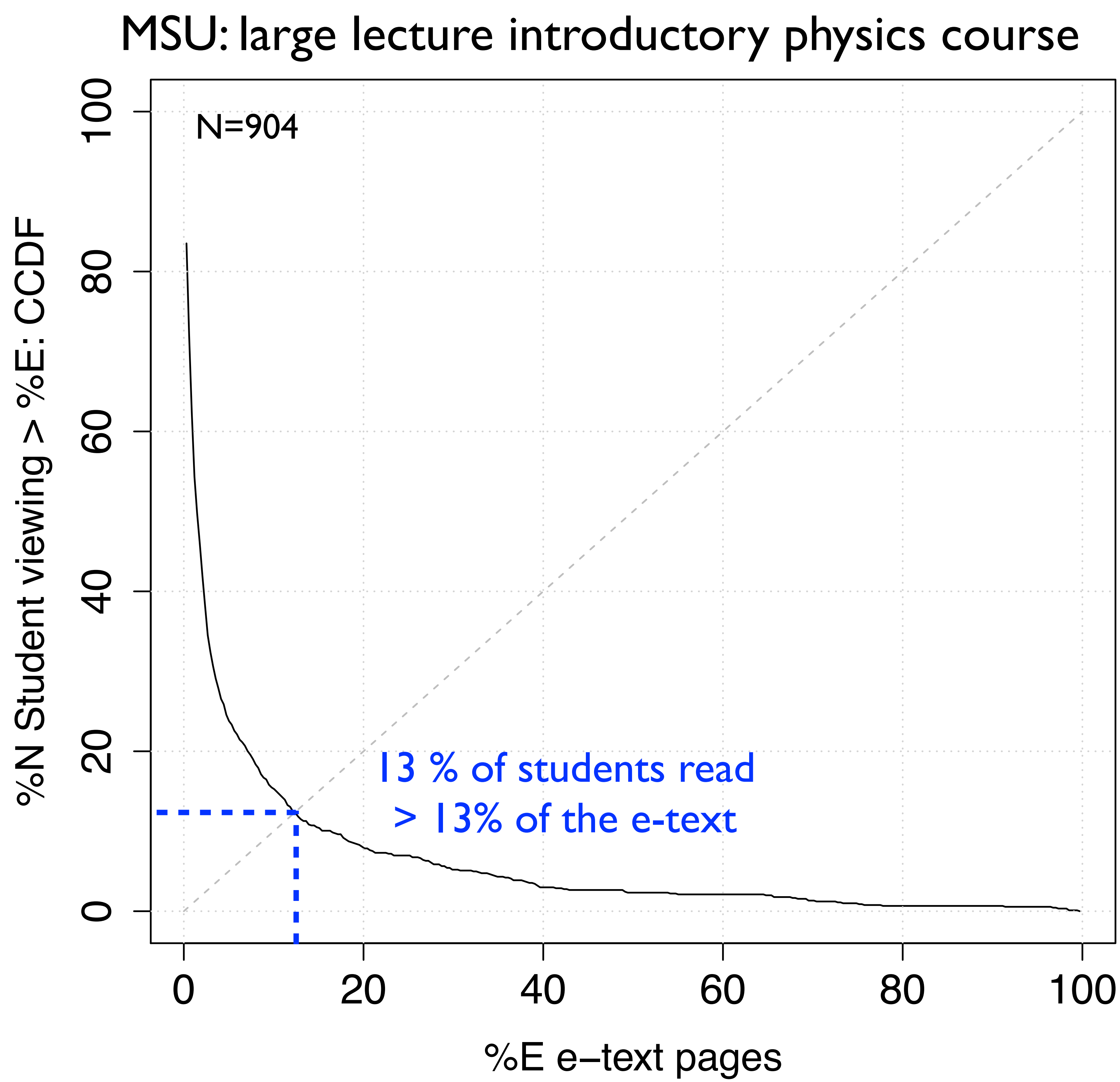

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  - RELATE, previous research, course structure
- Courses/Data
- Methodology
  - Sever logs, activity and overall usage, time spent
- Examining e-text use in blended courses
  - Samples from MSU and MIT
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Blended 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

MSU Courses	Students	e-text	Exams	e-text assessment
Supplementary A	898	Secondary	3 + final	No
Supplementary B	911	Secondary	3 + final	No
Supplementary C	808	Secondary	2 + final	No
Traditional A	159	Primary	2 + final	No
Traditional B	190	Primary	2 + final	No
Reformed A	211	Primary	6 + final	Yes
Reformed B	209	Primary	6 + final	Yes
Reformed C	197	Primary	6 + final	Yes
Reformed D	254	Primary	6 + final	Yes
MIT Reformed	37	Primary	12 + final	Yes

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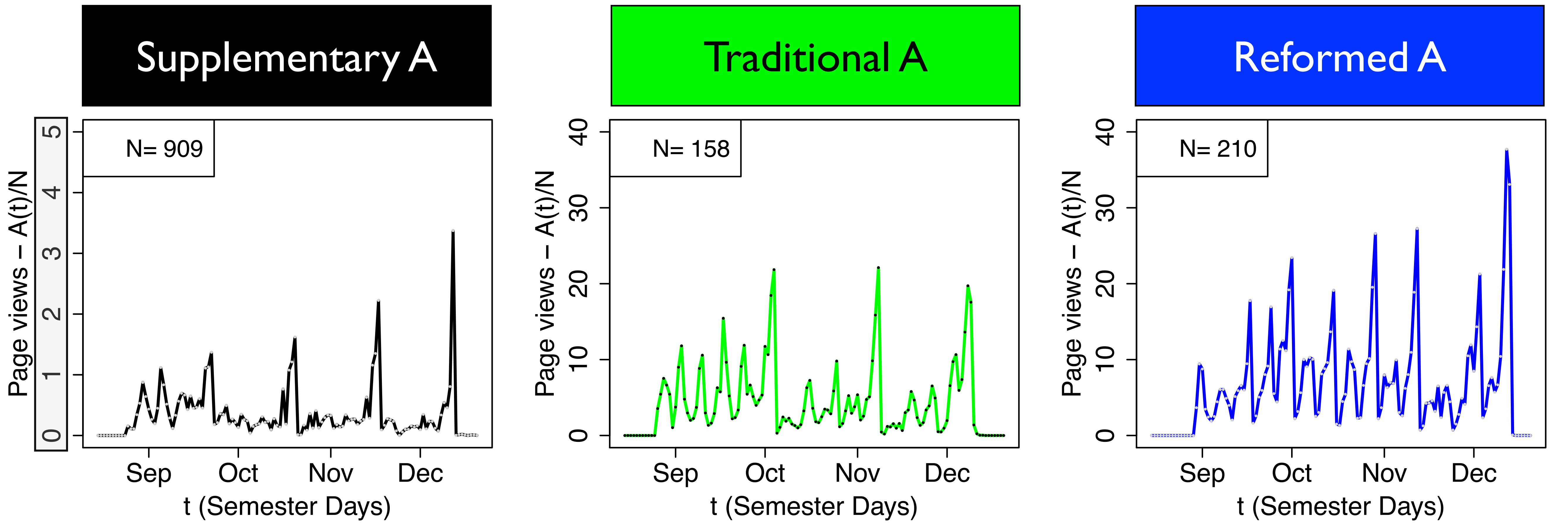
Reformed B	209	Primary	6 + final	Yes
Reformed C	197	Primary	6 + final	Yes
Reformed D	254	Primary	6 + final	Yes
MIT Reformed	37	Primary	12 + final	Yes

Blended courses: e-text activity per day



- Large spikes indicate exams
- Weekly activity after first exam decreases in Supplementary and Traditional courses

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General usage: *percentage of e-text viewed*

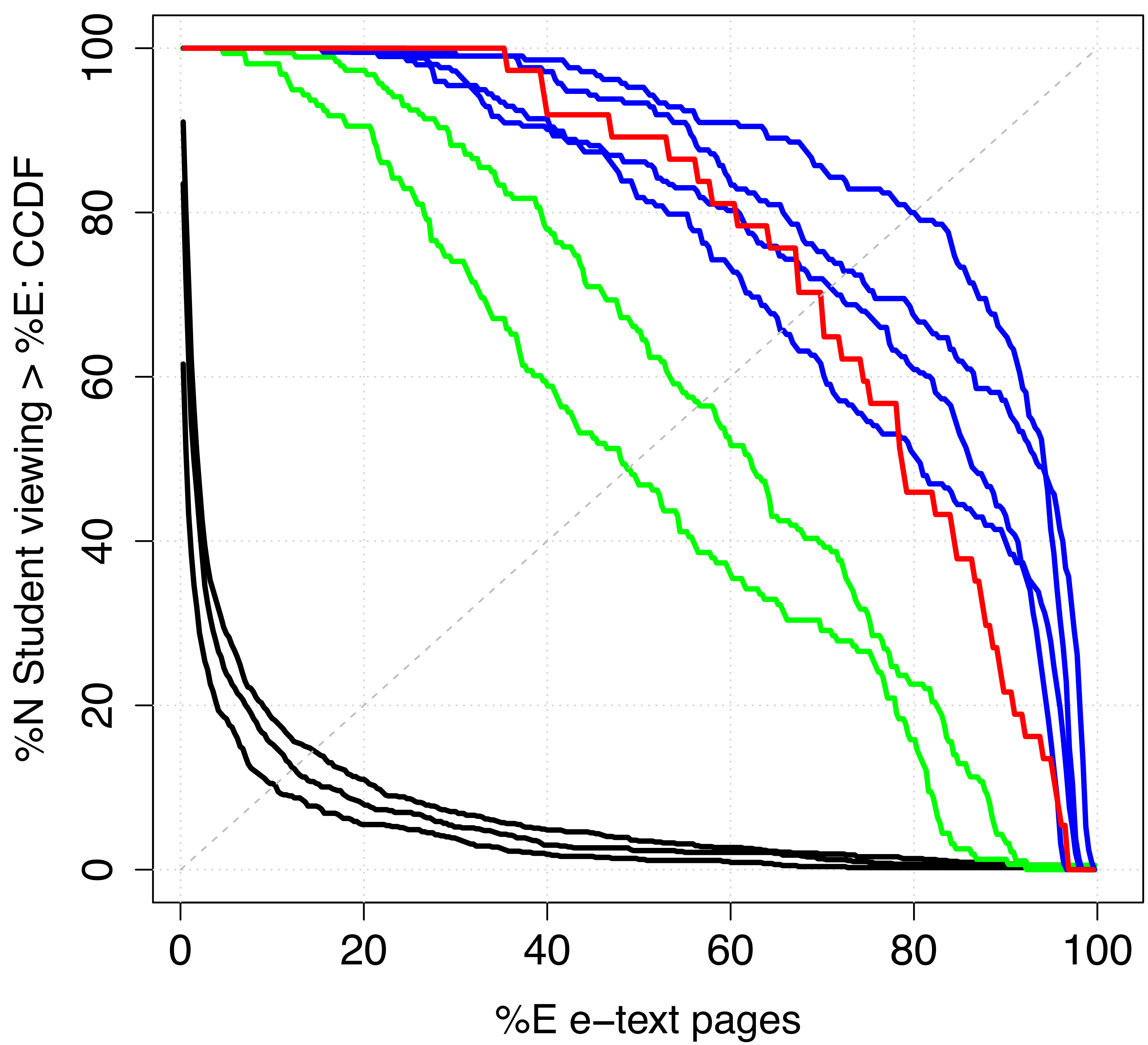
Supplementary

Traditional

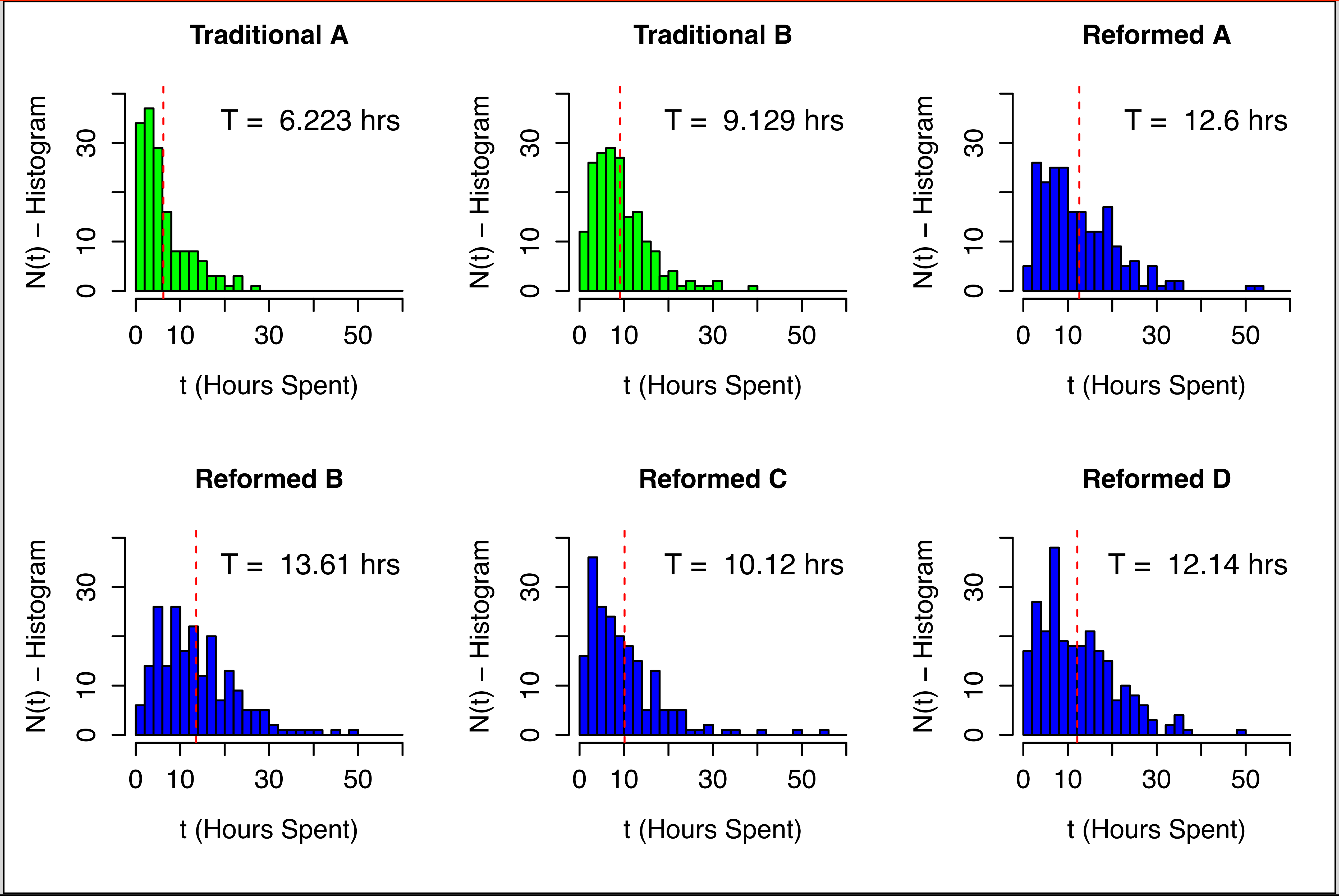
Reformed

- Categories span usage cases
- Reformed courses have greatest percentage of e-text viewed

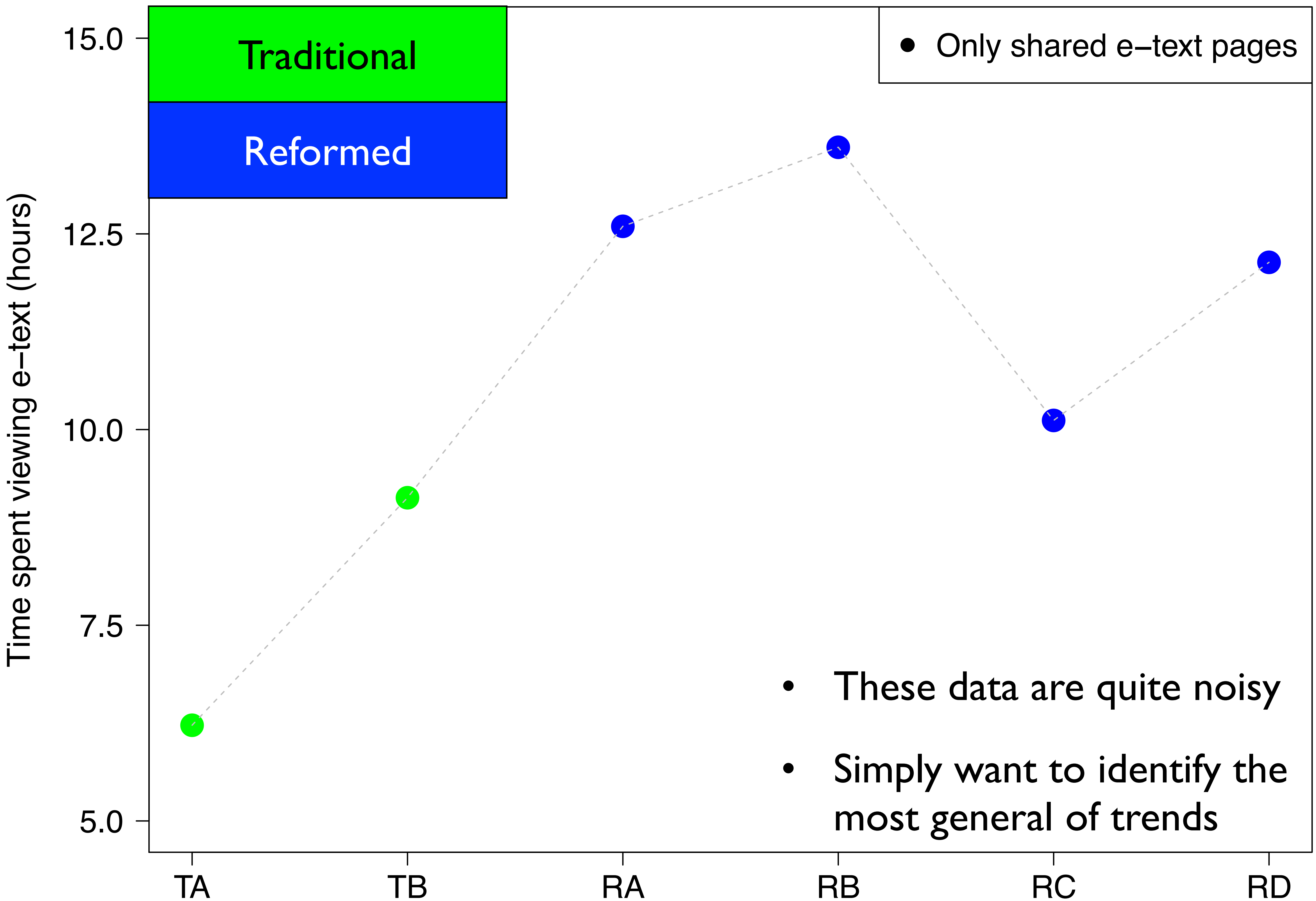
MIT Reformed



Time spent viewing the *identical* e-text

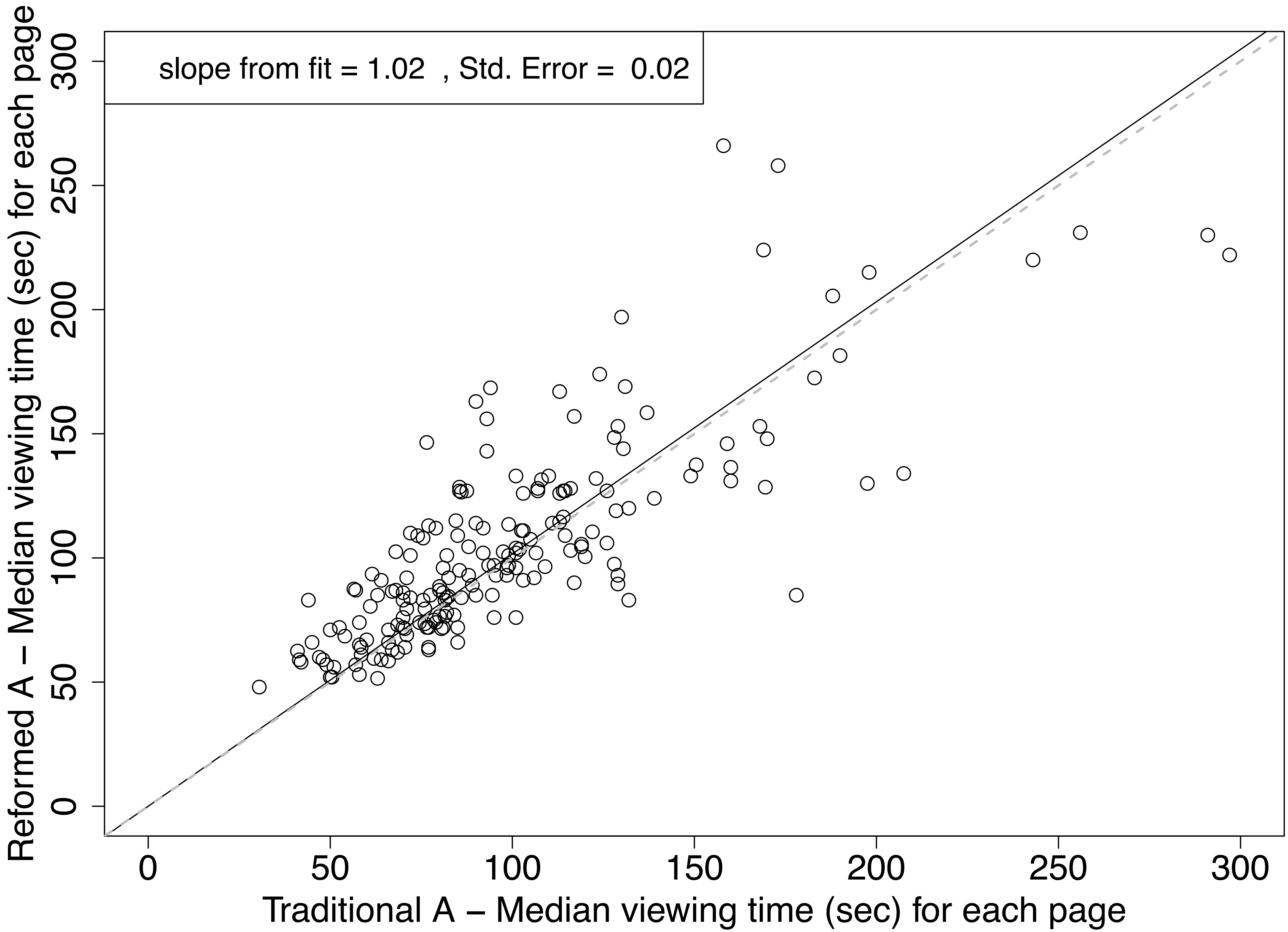


Mean time spent viewing the *identical* e-text

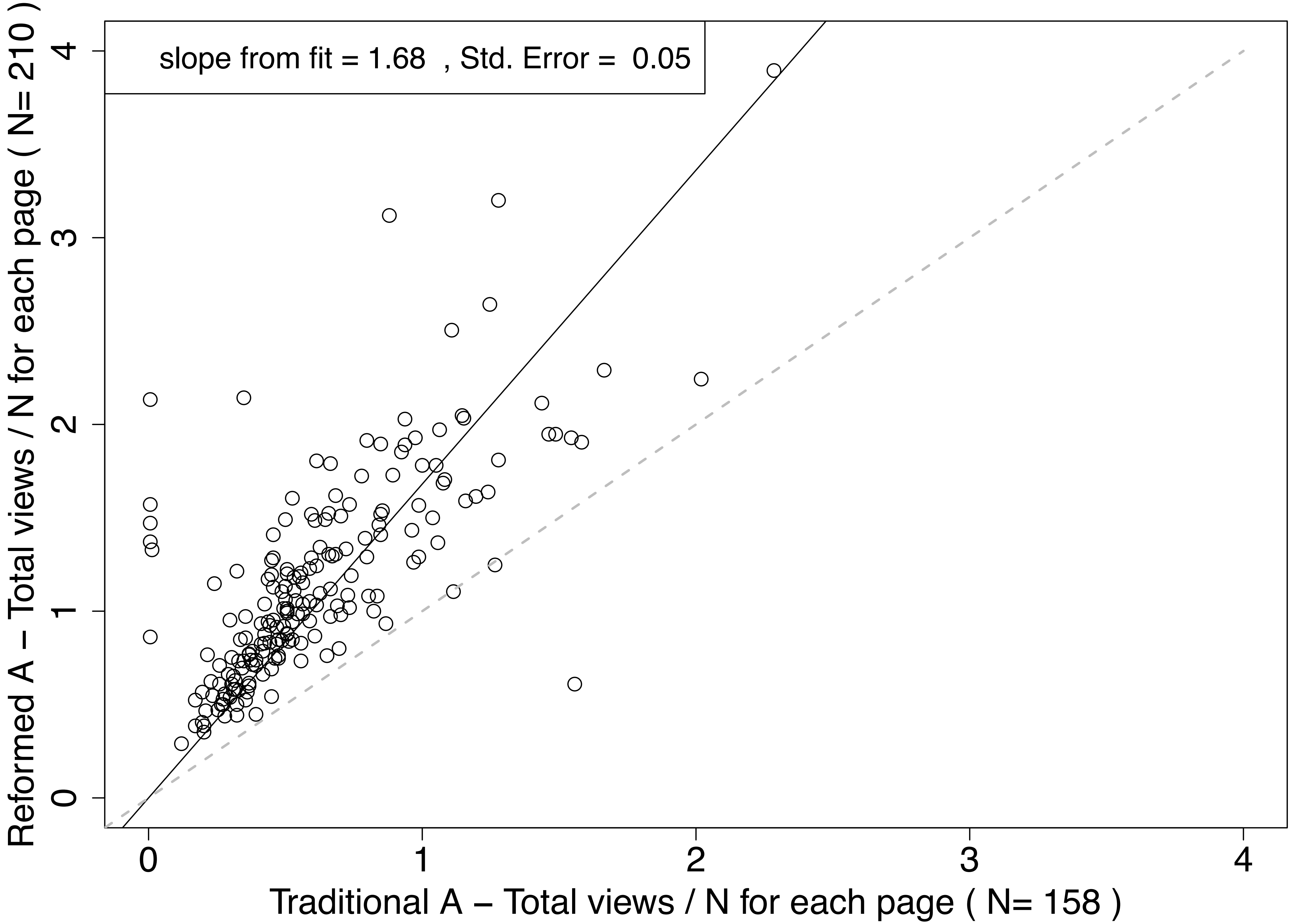


- These data are quite noisy
- Simply want to identify the most general of trends

Median time each page: Trad. A vs Reform. A



Total e-text views/student: Trad. A vs Reform. A



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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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

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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)

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Classification by course structure

MSU Courses	Students	e-text	Exams	e-text assessment
Traditional A	155	Primary (344)	4 + final	No
Traditional B	231	Primary (344)	4 + final	No
Traditional C	165	Primary (341)	3 + final	No
Traditional D	187	Primary (343)	3 + final	No
Traditional E	163	Primary (481)	3 + final	No
MIT Courses	**Active Students**			
Mech Online A	~ 70	Primary (281)	10 quizzes	Yes
Mech Online B	~ 100	Primary (323)	10 quizzes	Yes
6.002x	~ 7000	Secondary (1009)	1 + final	No

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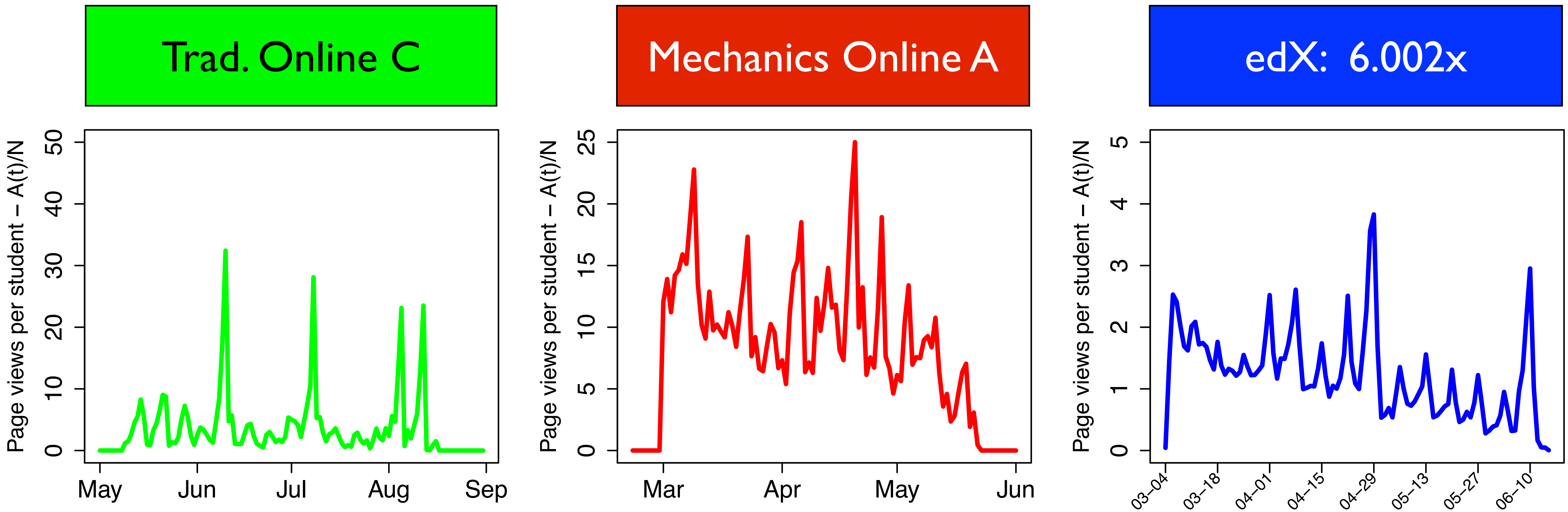
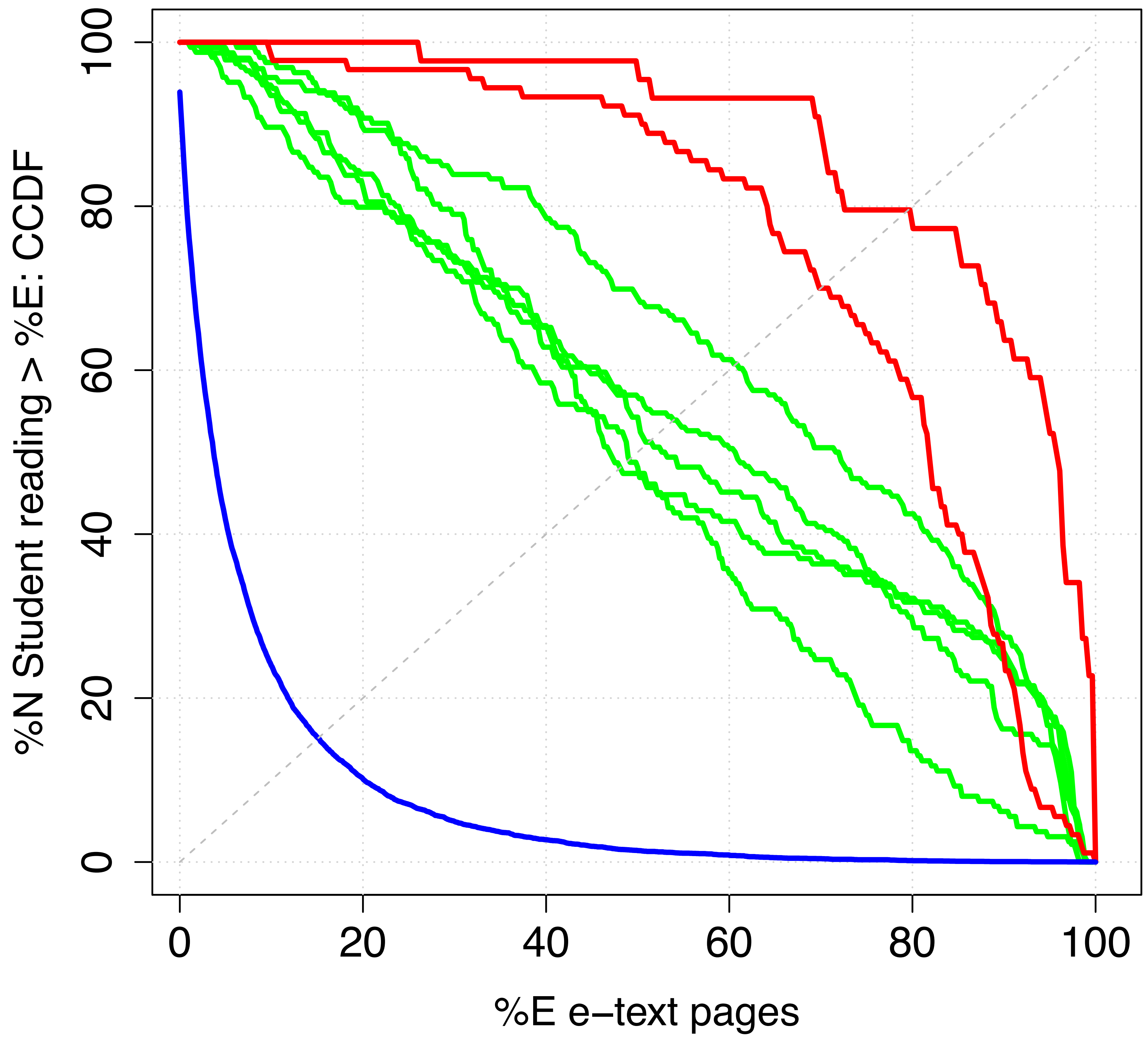
Online courses: e-text activity per day



- *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



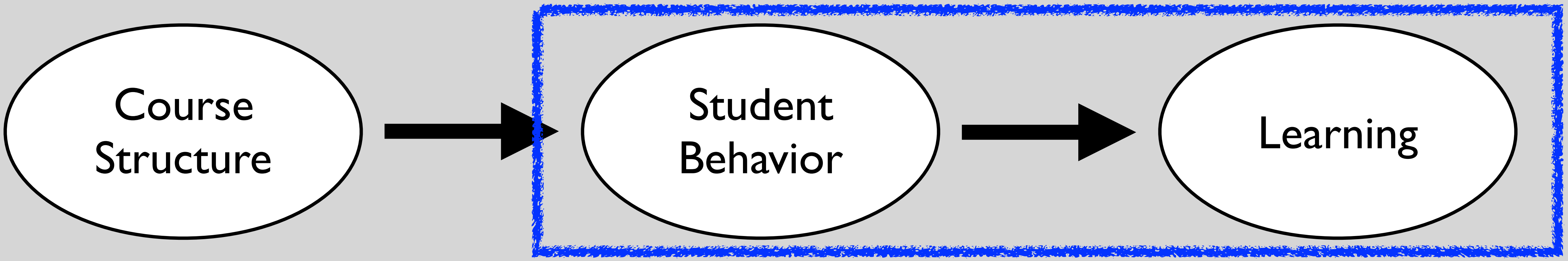
Summary: Online courses MSU, MIT, and edX

- 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



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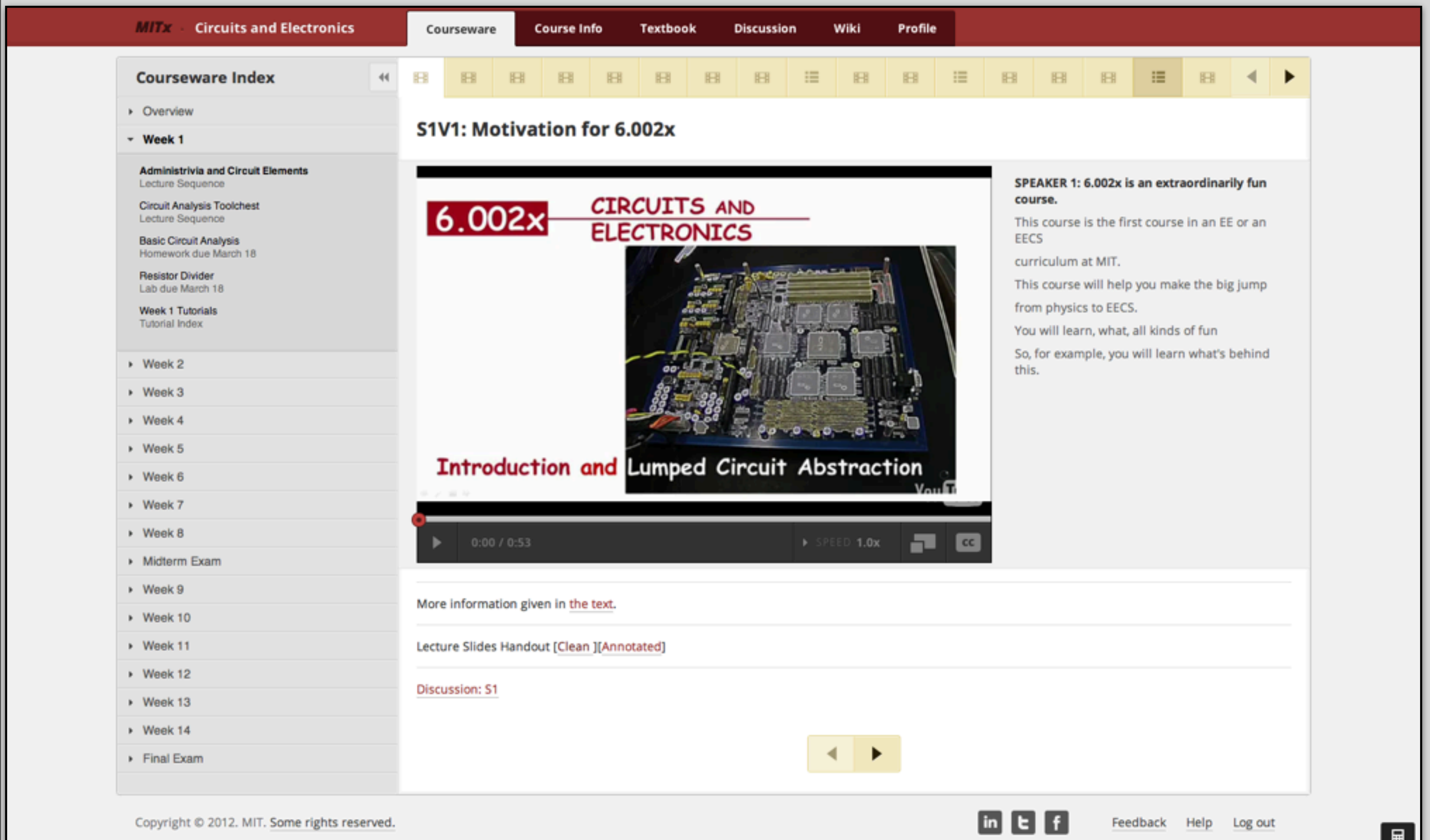
Current... Future work

- 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



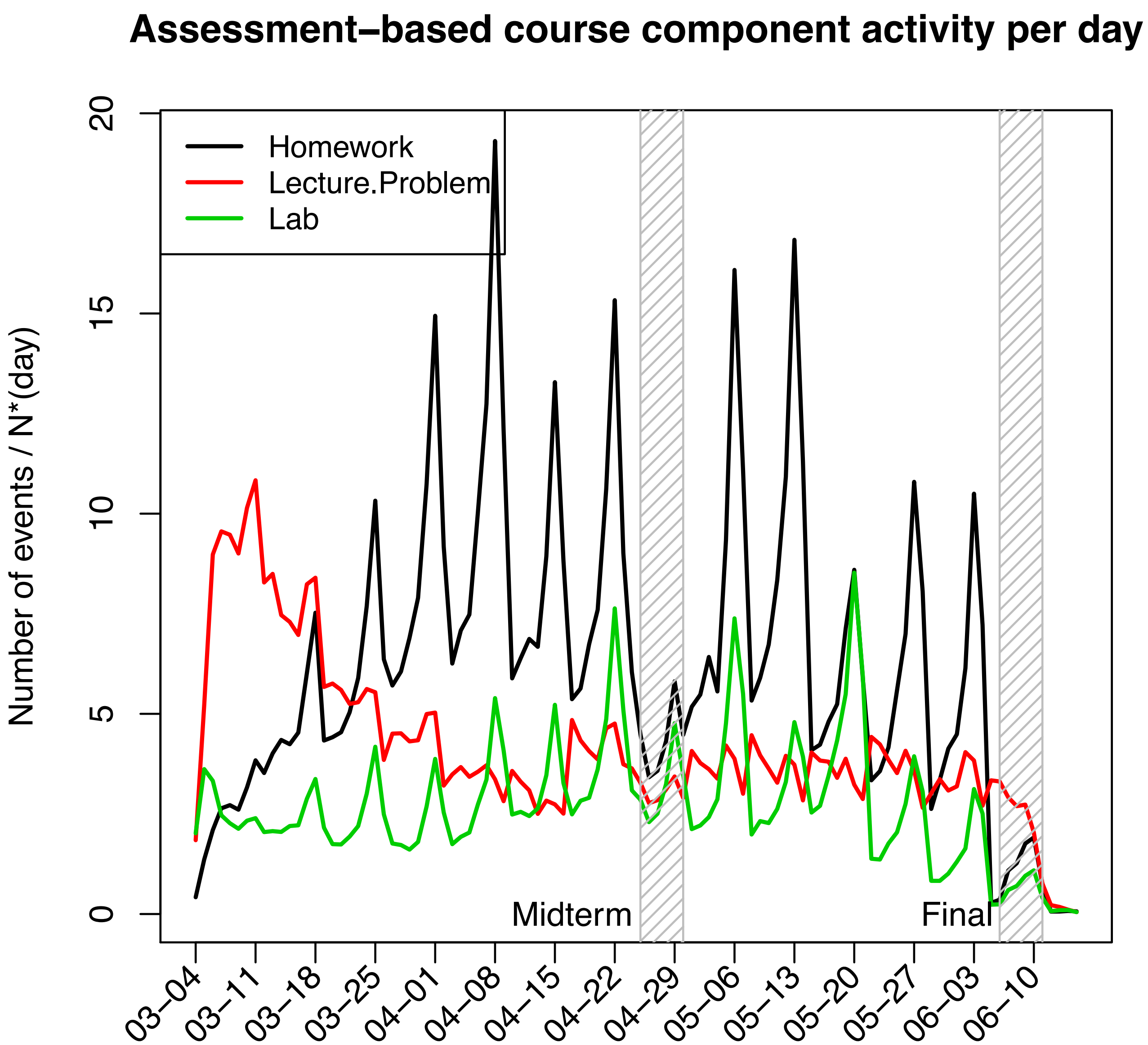
- N ~ 10,000 per course
- Course components:
  - Homework
  - Laboratory
  - Lecture Videos/Exercises
  - Discussion
  - e-text
  - Wiki
  - Exams

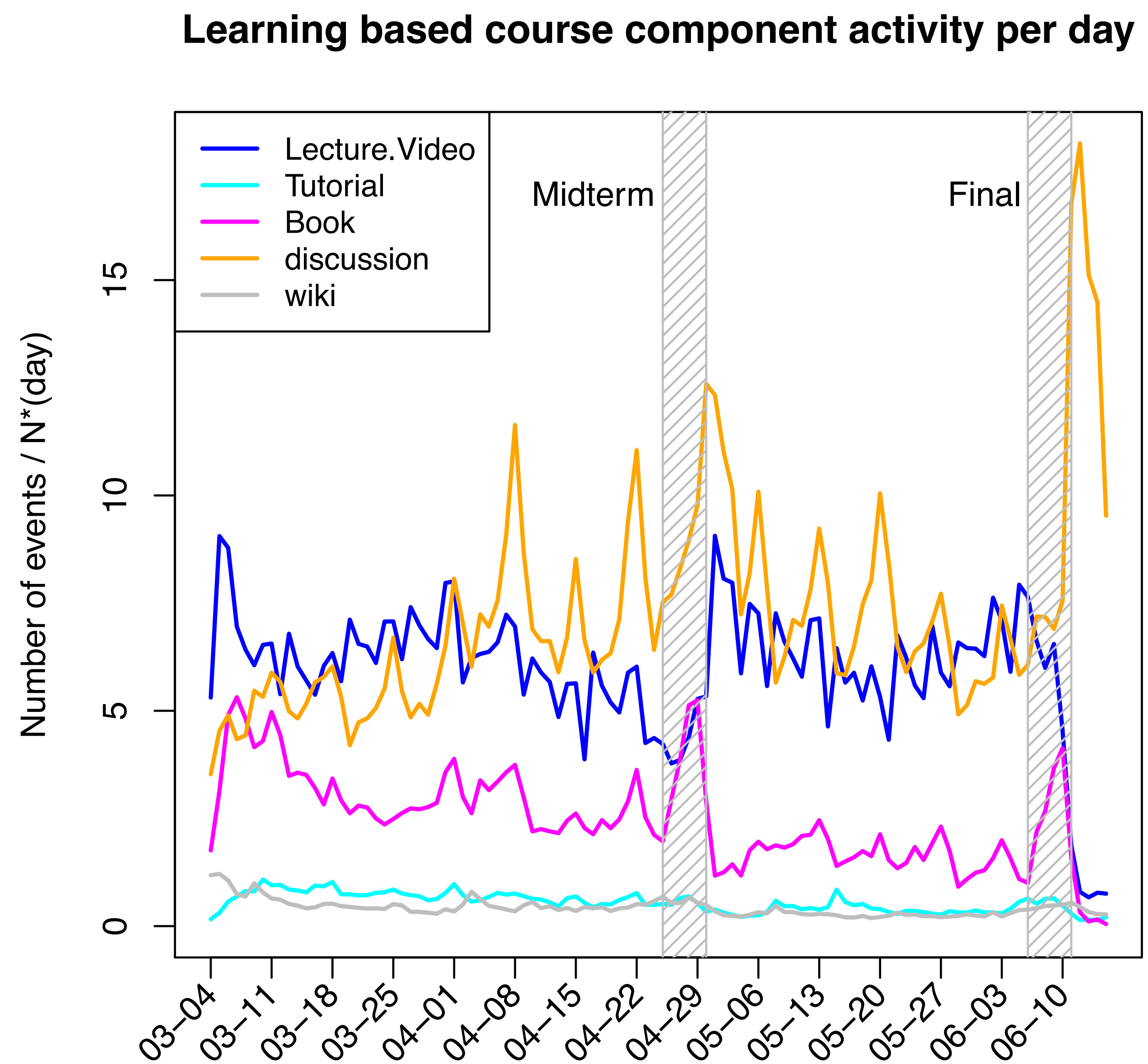
Future: Time spent on course components

- 6.002x: Different data set, but provides many more resources to track
  - *Homework*, *Lect. Videos*, *Lab*, *Lect. Probs*, *Textbook*, *Tutorials*, *Discussion*, *Wiki*

6.002x: *inaugural course for edX*

N = 7159 midterm and final examinees





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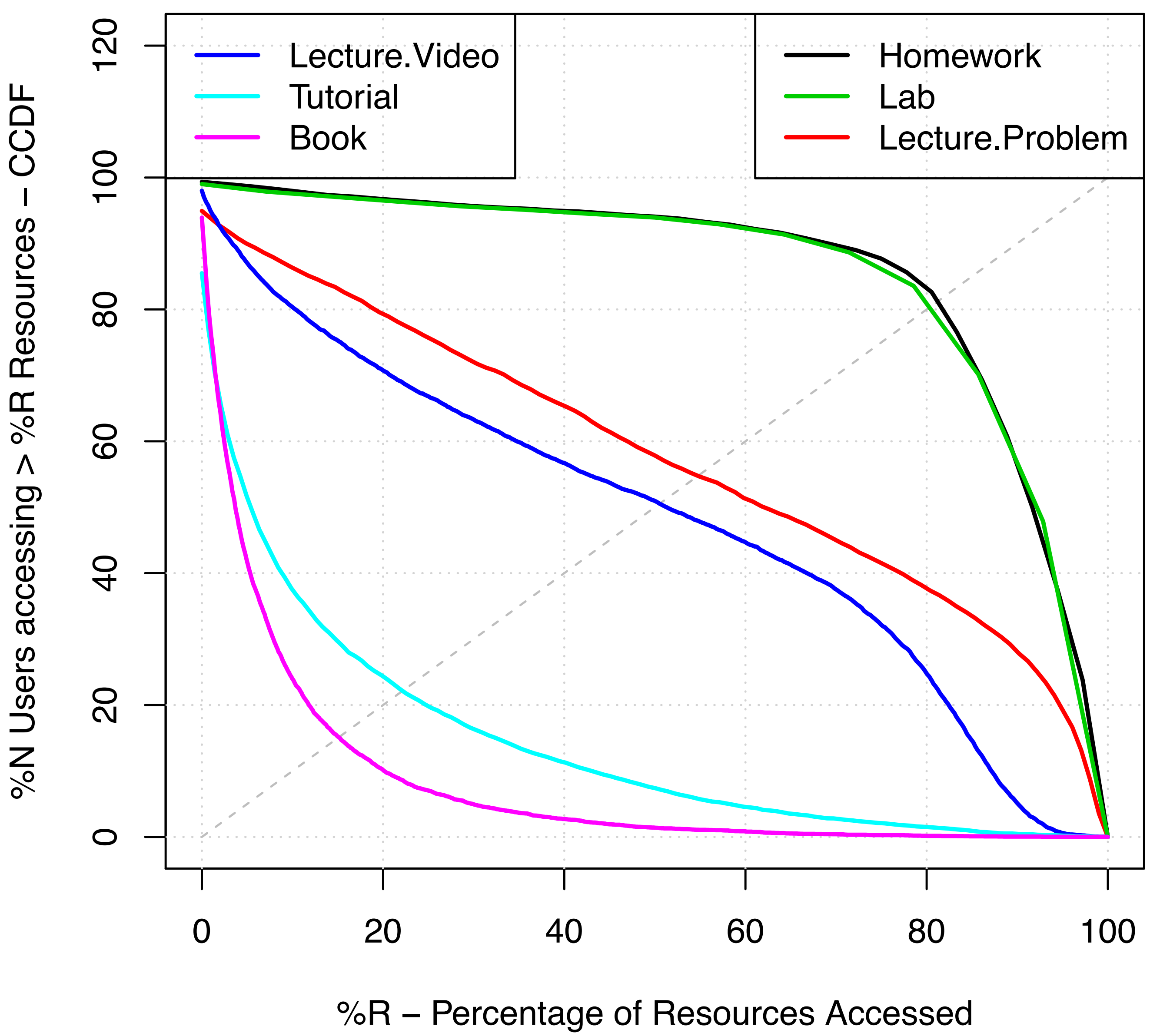
Future: Time spent on course components

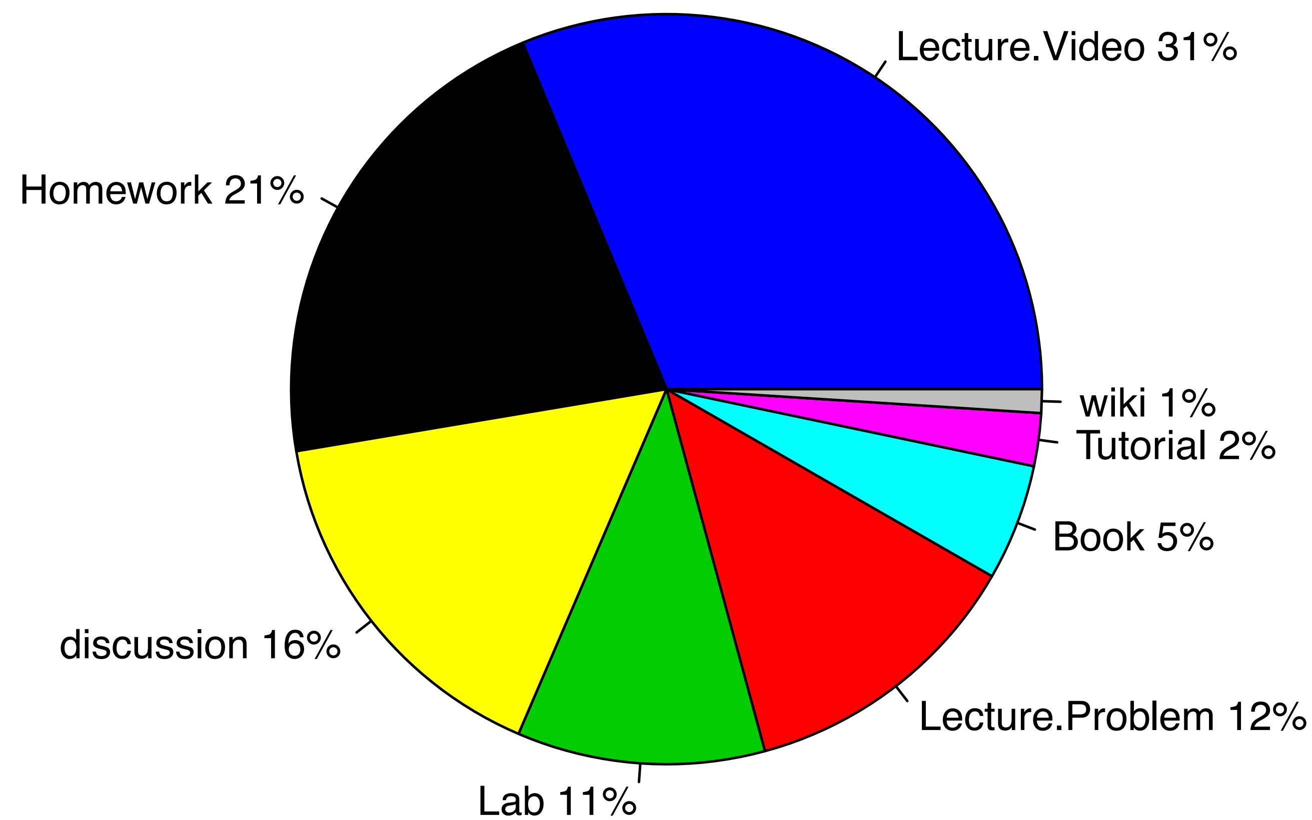
- 6.002x: Different data set, but provides many more resources to track
  - *Homework, Lect. Videos, Lab, Lect. Probs, Textbook, Tutorials, Discussion, Wiki*

6.002x: *inaugural course for edX*

N = 7159 midterm and final examinees



Percentage of time spent on course components



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Thank you for your time!

References

[1] - "Student Textbook Use in Introductory Physics", Cummings, French, Cooney, *Proceedings of Physics Education Research Conference, (2002).*

[2] - "The Perceived Value of College Physics Textbooks", Podolefsky, Finkelstein, *The Physics Teacher, (2006).*

[3] - "Want to Reduce Guessing and Cheating While Making Students Happier? Give More Exams!",

Laverty, Bauer, Kortemeyer, and Westfall, *The Physics Teacher*, (accepted 2012).

[4] - "Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology",

Haak, HilleRisLambers, Pitre, and Freeman, Science, Vol. **332,** 1213 (2011)

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