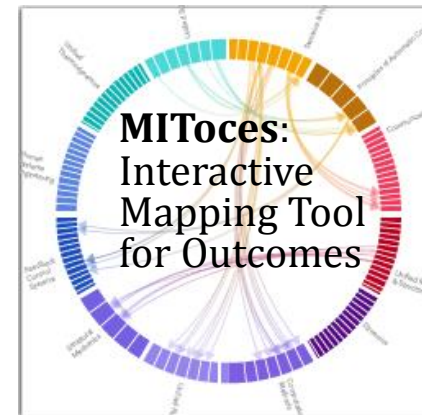
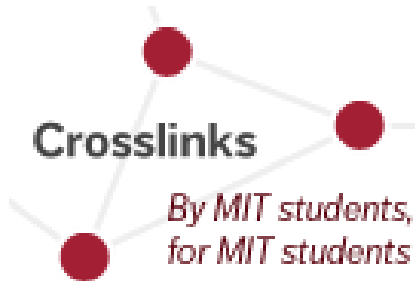




# Mapping Learning Outcomes and Topics across the MIT Curriculum

MIT ODL xTalks Series  
May 6<sup>th</sup>, 2015



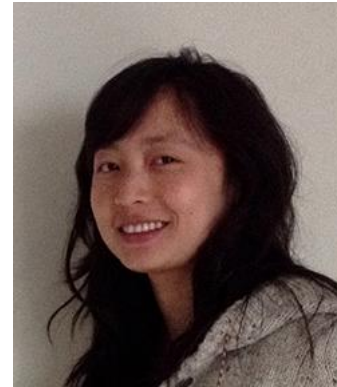
# The Team



Karen Willcox



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Emma Nelson



# Outline

- Why map?
- Mapping outcomes  
<http://mitoces.mit.edu/>
- Mapping topics  
<http://crosslinks.mit.edu/>

# Our terminology

## A learning outcome

“what a student is expected to be able to **do** as a result of a learning activity”

## A prerequisite outcome

“an outcome that a student is required to have achieved before s/he can achieve another related outcome”

## A module

“a learning unit comprised of a set of outcomes”  
(generally relatively self-contained)

# Why map?

To understand and document what we are teaching

- Catalog measurable outcomes and prerequisite relationships
- Maintain unified repository for outcomes across the Institute (“sequencing the DNA of the MIT undergraduate curriculum”)
- Communicate clear expectations to students

# Why map?

To connect the pieces

- Contextualize learning for students by providing roadmap
- Connect faculty across subjects, departments, schools
- Catalyze discussion about different types of outcomes and what it means to be a graduate of the mapped program (cf. CDIO, ABET)

# Why map?

To enrich our ability to revisit, refresh, re-use learning resources

- Make modular learning and assessment resources readily available with context.
- Navigate easily through related learning resources
- Connect resources to specific outcomes

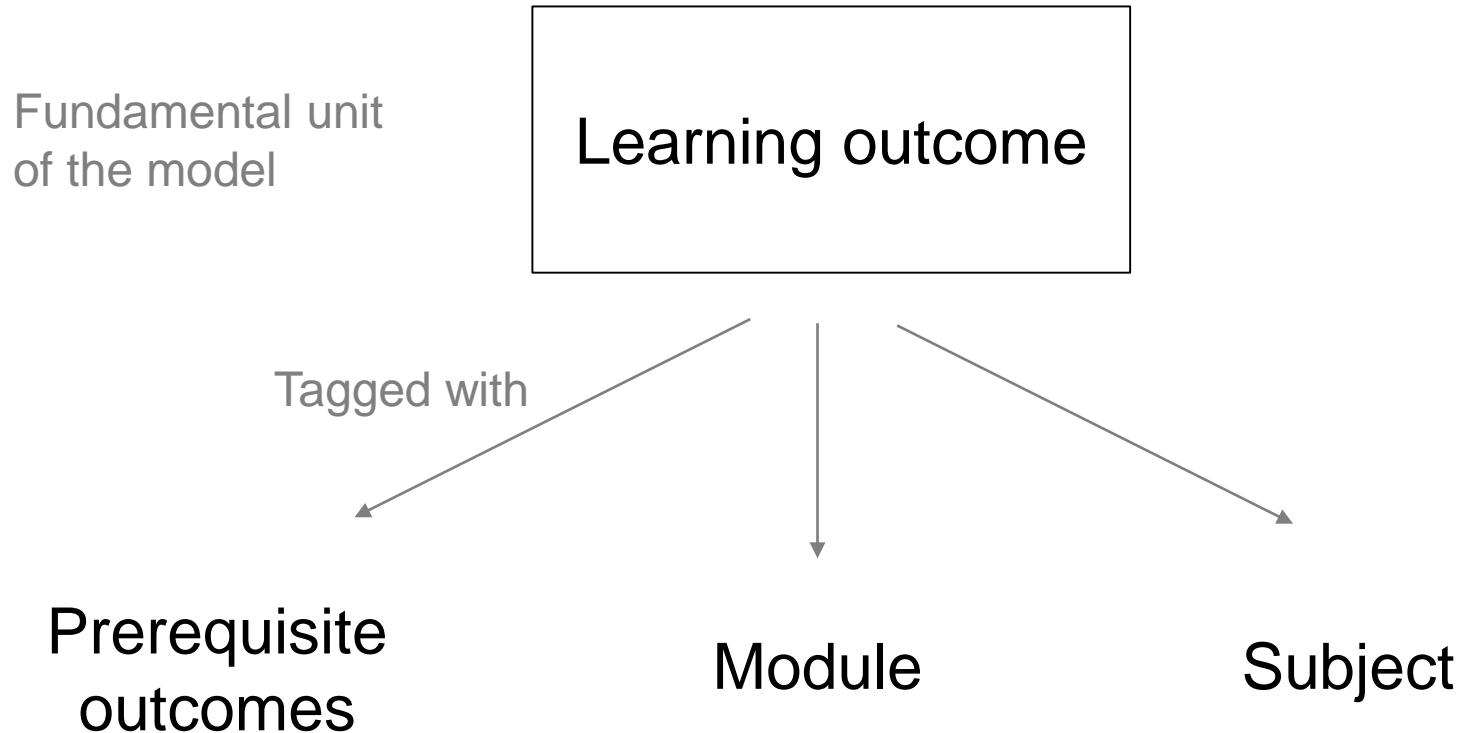
# Why map?

To inform our future educational innovations

- Identify opportunities for modularity in the curriculum
- Identify opportunities for flexibility in the curriculum
- Create opportunity for competency-based assessment
- Enable personalized education and automatic recommendations



# Mapping outcomes: Our model



# Mapping outcomes: Our process

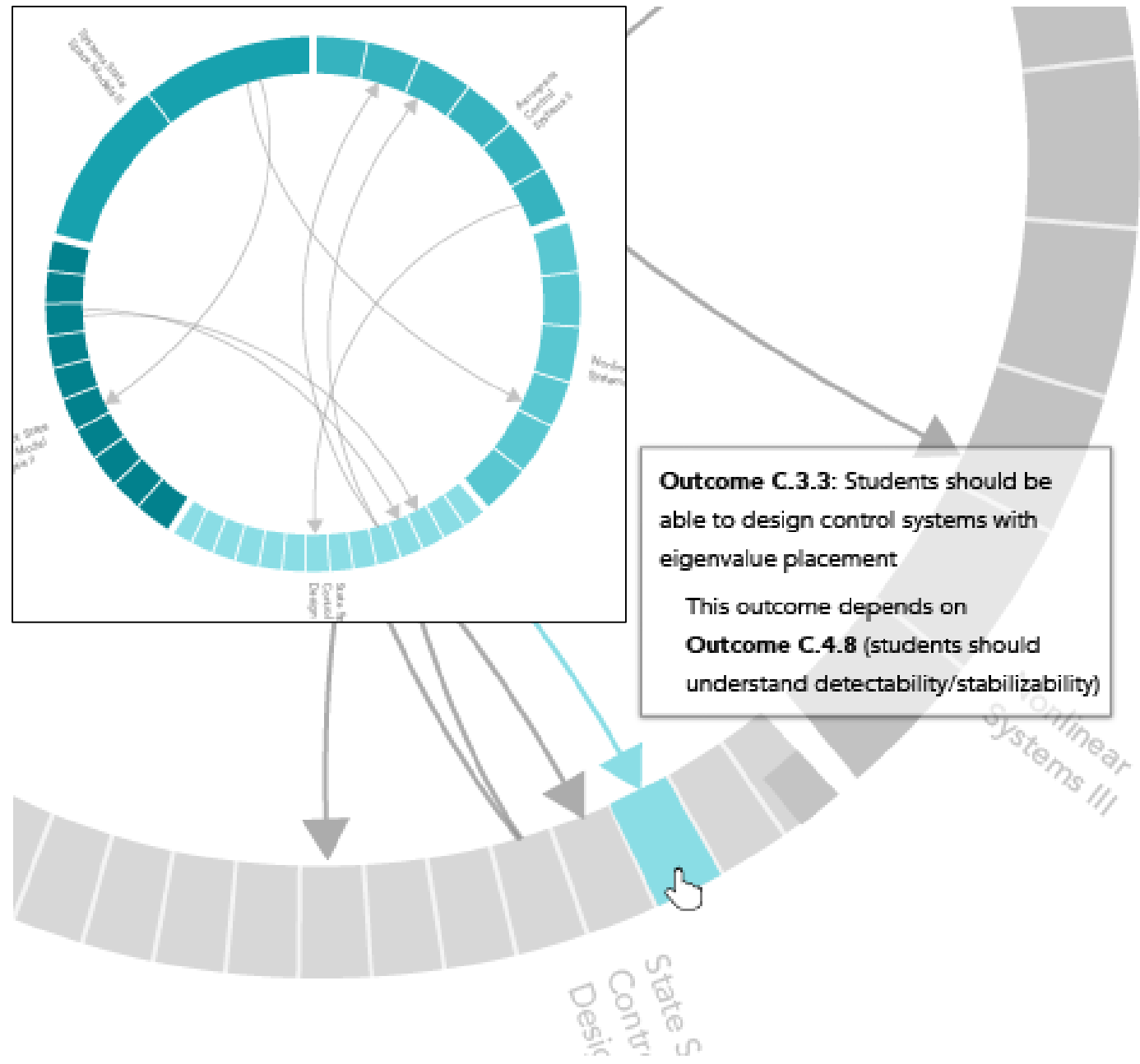
1. **Initial meeting** with faculty to outline goals of the project and explore any existing outcomes
2. If up-to-date outcomes, worked together to **edit the outcomes** to fit the project format by adjusting syntax or granularity  
If no up-to-date outcomes, reviewed subject materials (syllabi, lecture notes, psets) to propose **new set of outcomes**
3. Once an initial set of outcomes was agreed upon, worked together to group outcomes into modules and **develop links between outcomes** in the subject
4. Made **links between outcomes in the subject and prerequisite outcomes in other subjects**
5. Interest-groups of faculty met to discuss **sequences of subjects** and revise the outcomes and links within them

**Output: a comprehensive draft of outcomes with department-wide approval.**

# Mapping outcomes: Our status

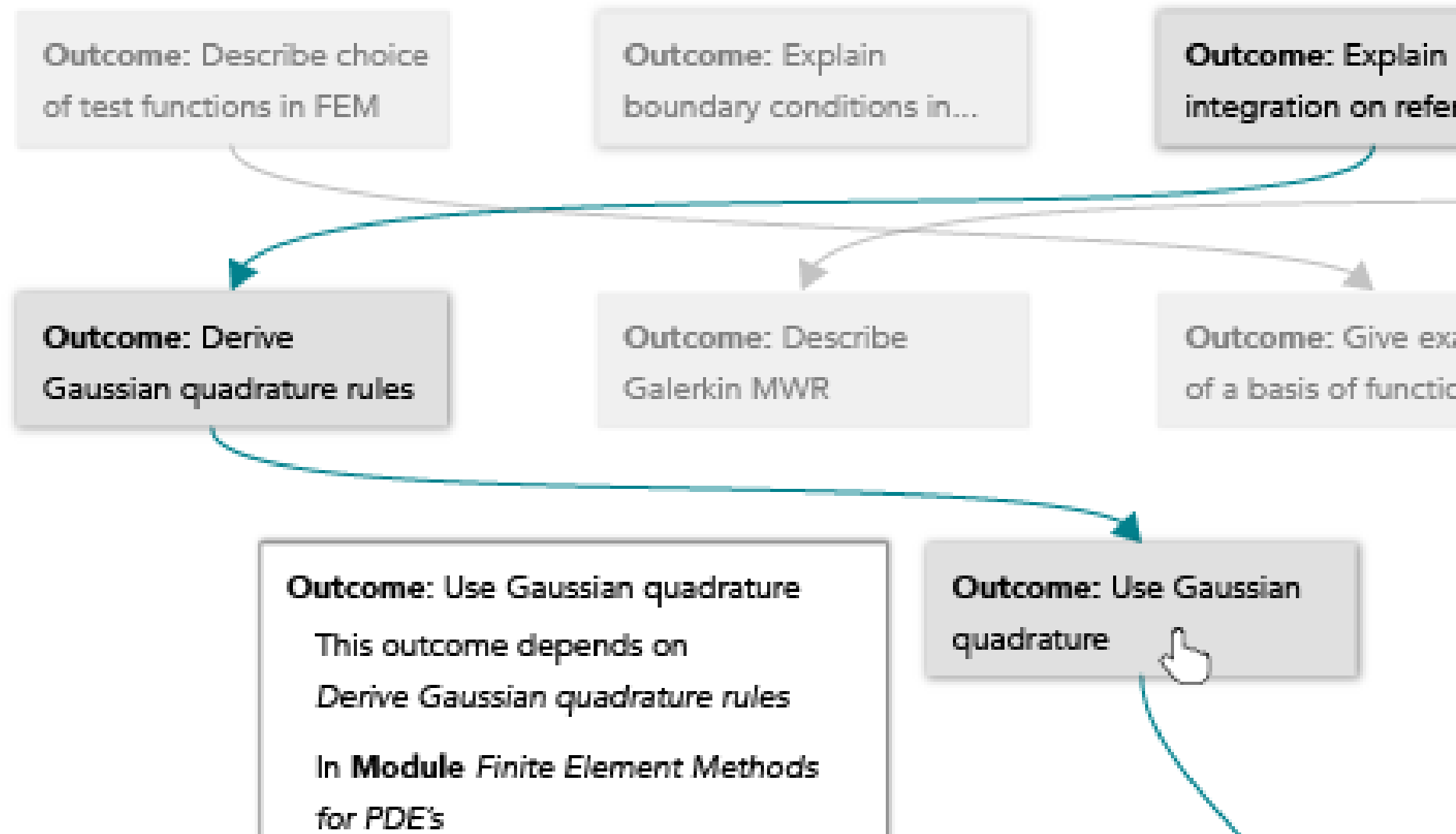
- More than **1100 outcomes** collected across **29 subjects**:  
  
all Course 16 subjects in UG curriculum that contribute towards degree requirements  
  
plus 8.01, 8.02, 18.01, 18.02, 18.03, 3.091
- Begun to collect documented outcomes from other subjects' webpages (6.02 and 6.041)
- Many linkages between subjects are in place; we are working to populate the database of linkages

# A feedback controls subject partitioned into five modules

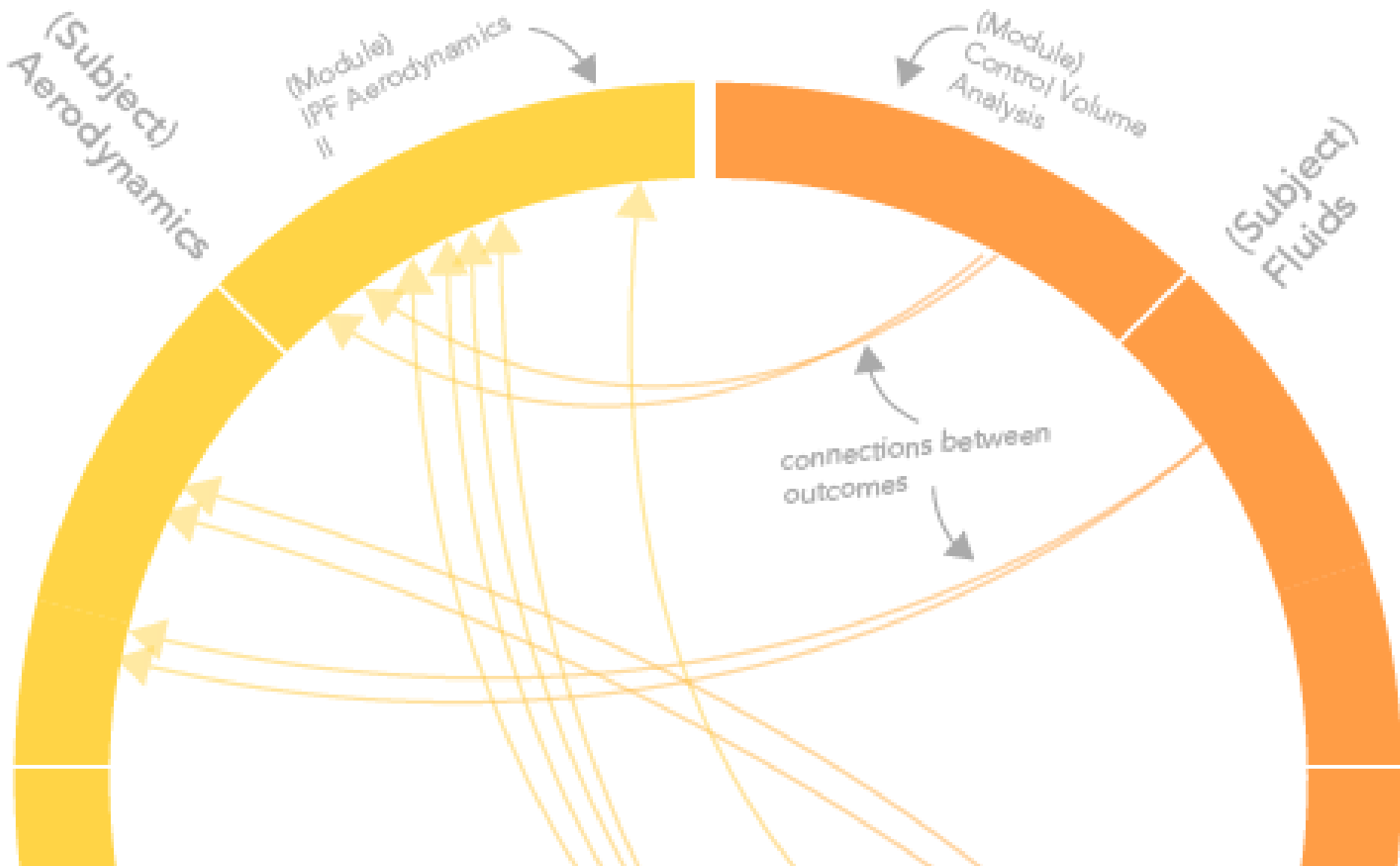


# Outcomes arranged within a module

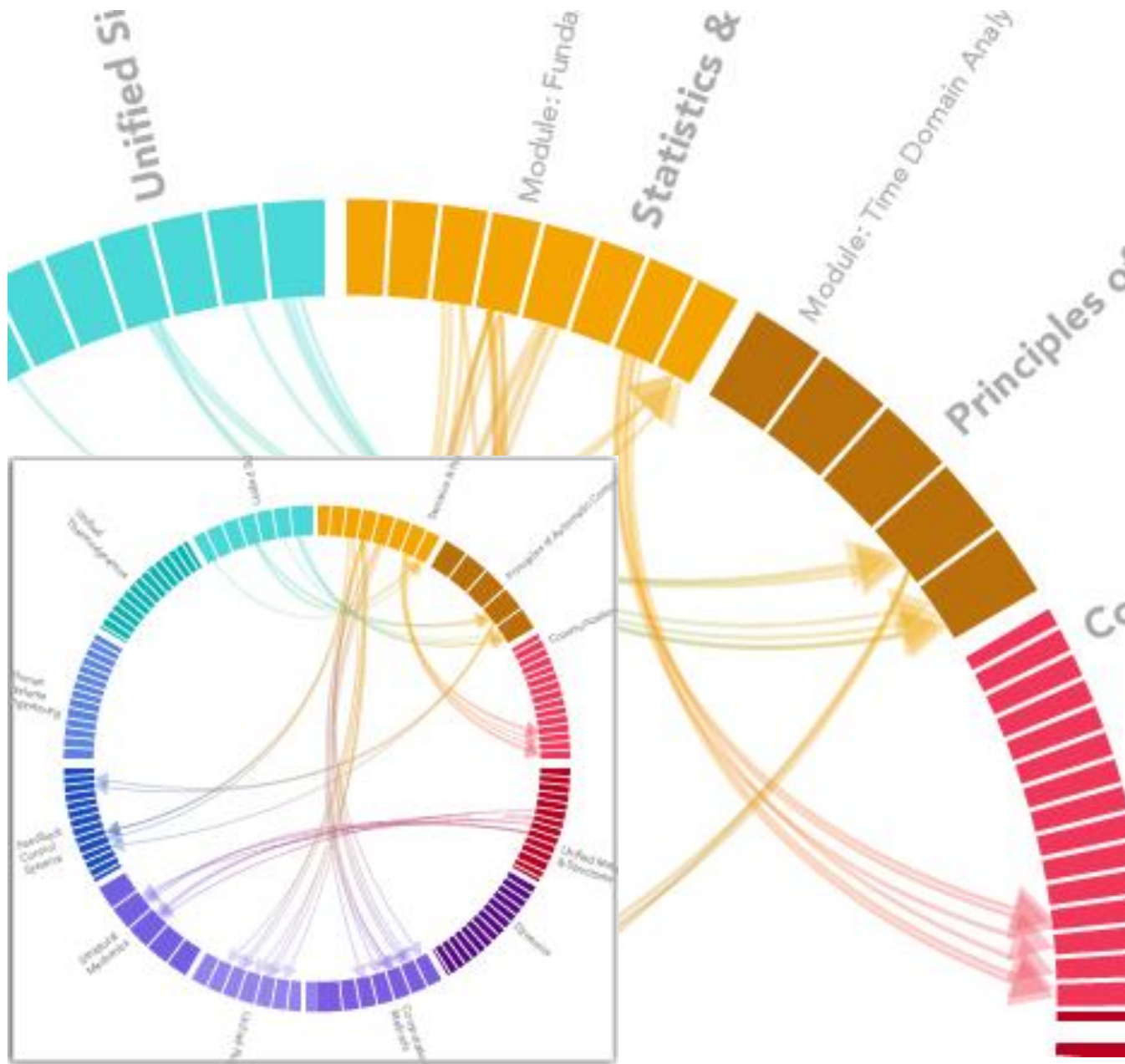
MIT > Aeronautics & Astronautics > Computational Methods > Finite Element Methods for PDE's



# Interconnections between two subjects



## Visualizing multiple subjects and modules



# Embedding MIToces in lecture notes



MITx: 16.90r Computational Methods in Aerospace Engineering



Courseware

Course News

Syllabus

Discussion

MIToces

MO Index

Progress

Courseware

Course News

Syllabus

Discussion

MIToces

MO Index

Progress

## Overview of 1690r

### Numerical Integration of Ordinary Differential Equations

#### Overview

due Mar 10, 2014 at 09:00 UTC

#### Discretizing ODEs

Embedded Questions due Feb 10, 2014 at 14:00 UTC

#### Accuracy

Embedded Questions due Feb 10, 2014 at 14:00 UTC

#### Convergence

Embedded Questions due Feb 18, 2014 at 14:00 UTC

#### Zero Stability and the Dahlquist Equivalence Theorem

Embedded Questions due Feb 18, 2014 at 14:00 UTC

#### Systems of ODE's and Eigenvalue Stability

Embedded Questions due Feb 18, 2014 at 14:00 UTC

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#### Zero Stability and the Dahlquist Equivalence

### 1.7.2 SPECTRAL CONDITION NUMBER (1 point possible)

MO1.9

MO1.11

MO1.12

Stiffness can also be characterized by the magnitudes of the eigenvalues. For example, if the eigenvalues are significantly different

MO 1.11: Explain the concept of stiffness of a system of equations

$$u_t = Au, \quad A = \begin{pmatrix} -1 & 1 \\ 0 & -1000 \end{pmatrix}.$$

The eigenvalues of  $A$  are  $\lambda = -1$  and  $\lambda = -1000$ . Since the time step must be set so that both eigenvalues are stable, the larger eigenvalue will dominate the timestep. The spectral condition number is the ratio of the largest to smallest eigenvalue magnitudes,

(1.120)

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$$\text{Spectral Condition Number} = \frac{\max |\lambda_j|}{\min |\lambda_j|} \quad (1.121)$$



# Embedding MIToces in lecture notes



## Measurable Outcome Index

### NUMERICAL INTEGRATION OF ORDINARY DIFFERENTIAL EQUATIONS

**MO1.1** Define a first-order ODE.

**MO1.2** Use analytical solutions to validate numerical solutions of ODE.

**MO1.3** Distinguish nonlinear ODEs from linear ODEs.

**MO1.4** Approximate the behavior of a nonlinear equation with a linear one.

**MO1.5** Discretize a univariate function and its derivative, assess the truncation error using Taylor series analysis.

**MO1.6** Describe the Forward Euler methods and the Midpoint methods.

#### Learn

- [The Forward Euler Method](#)
- [The Midpoint Method](#)
- [Nonlinear Systems](#)
- [Eigenvalue Stability for a Linear ODE](#)

#### Assess

- [Example of Most Accurate Multi-Step Method](#)
- [Types of Errors](#)

**MO1.7** Assess whether a numerical method converges, and calculate its global order of accuracy.

# Has the outcomes mapping process been useful?

- Outcomes data collected so far has been used to:
  - Structure the use of the MITx platform in teaching 16.90 and 16.06
  - Help inform changes in Unified
  - Streamline content between Unified Fluids and 16.100
  - Inform a department-wide review of the AA UG curriculum
  - Identify specific issues/opportunities that need to be addressed (overlap/gaps between subjects, lack of outcomes in some subjects, lack of connections between subjects, connections with GIRs, etc.)

# Crosslinks



Tagging modular resources  
with granular topics across  
the MIT curriculum

Mapping how topics connect  
across courses

Experimenting with  
student-authored tagging of  
modular resources

## SIX FACETS OF COMPREHENSION

- 1 PREPARE** shows the prerequisites for a certain topic.
- The prerequisite chain enables the student to identify "gaps" and critical points in her abilities.

- 2 RELATE** shows closely-related topics for a certain topic.
- Through seeing related topics across MIT, the student gains a big picture understanding.

- 3 LEARN** is a collection of links to course notes, modular videos and mathlets that teach the topic.
- This aggregated collection of modular material enables the student to easily refresh specific topics.

### Learn



18.06 Linear Algebra: Voice-over demonstration



Mathlet: "Matrix vector"



Khan Academy: (Video) Example solving for the eigenvalues of a 2x2 matrix

## eigenvalue

- 4 ADVANCE** shows topics that follow after the current one.

By seeing which topics lie ahead, the student grasps the motivation and context for the current topic.

### Apply



Mathlet: Eigenvalue stability



MIT TLL Video: This video analyzes the rotation of a frisbee wobbling in flight. It is helpful to test your understanding of what eigenvectors represent, not just how to calculate them.

- 6 APPLY** is a collection of links to interesting applications of the topic in later courses or in industry usage.

This section answers the question, "How is this useful in the real world?"

- 5 ASSESS** is a collection of interactive finger exercises designed to assess the student's comprehension.

These exercises are drawn from selected MITx courses.

### Assess

True or false: The only eigenvector of  $\begin{pmatrix} 2 & -1 \\ 0 & 2 \end{pmatrix}$  is  $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ .

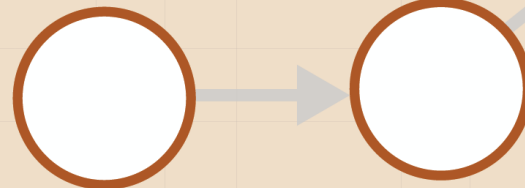
- ☐ True.  
☐ False.

CHECK

SHOW ME THE ANSWER

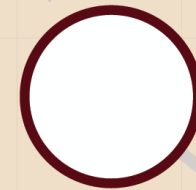
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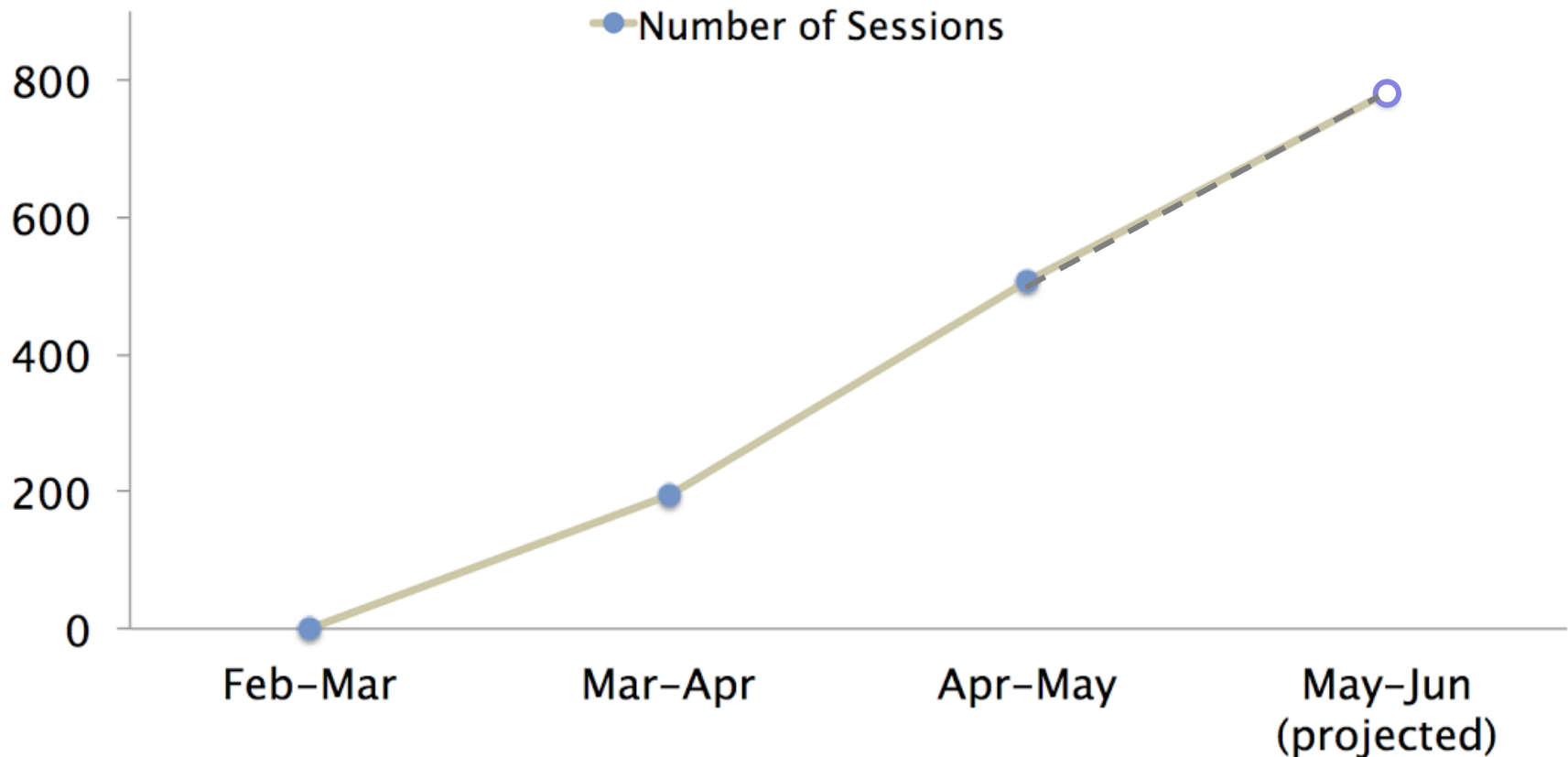
This section answers the question, "How is this useful in the real world?"



# Crosslinks adoption

In spring 2015, we launched Crosslinks to 18.03 and a table section of 8.02

## Undergraduate usage of Crosslinks



session = a visit in a contiguous time frame (set to 30min)

# Crosslinks adoption

Metric	April – May 2015
Users (students)	428
Sessions	564
Pageviews	3299

- In the past month, 428 undergraduate students used Crosslinks
  - 93 are returning users
- 6 students (outside of team) have edited => 1.4%
  - “In Internet culture, the 1% rule is a rule of thumb pertaining to participation in an internet community, stating that only 1% of the users of a website actively create new content, while the other 99% of the participants only lurk” – Wikipedia

# User behavior

We look at the behavior of Crosslinks users in April/May 2015  
(428 MIT UGs)

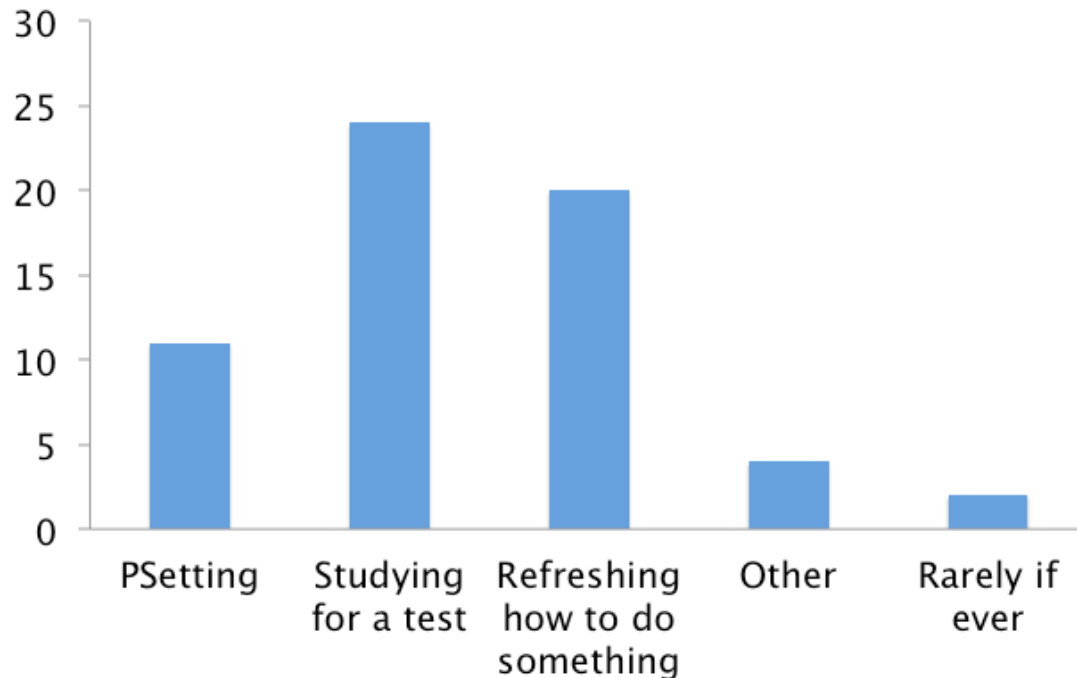
Metric	Crosslinks
Pages / session	7.06
Bounce rate	3.5%
Session duration	4:47 min

- High pages / session => students are visiting many pages
- Low bounce rates => students find the content engaging and relevant enough to visit other pages
- Long session durations => high levels of engagement
- OCW stats (6,587 MIT users): 5.39 pages/session; 28.5% bounce rate; 3.26 min session duration

# Assessment feedback (1/3)

Students were asked when they would (if ever) use the interactive exercises:

**When would you make use of the exercises?**



Interesting quotes:

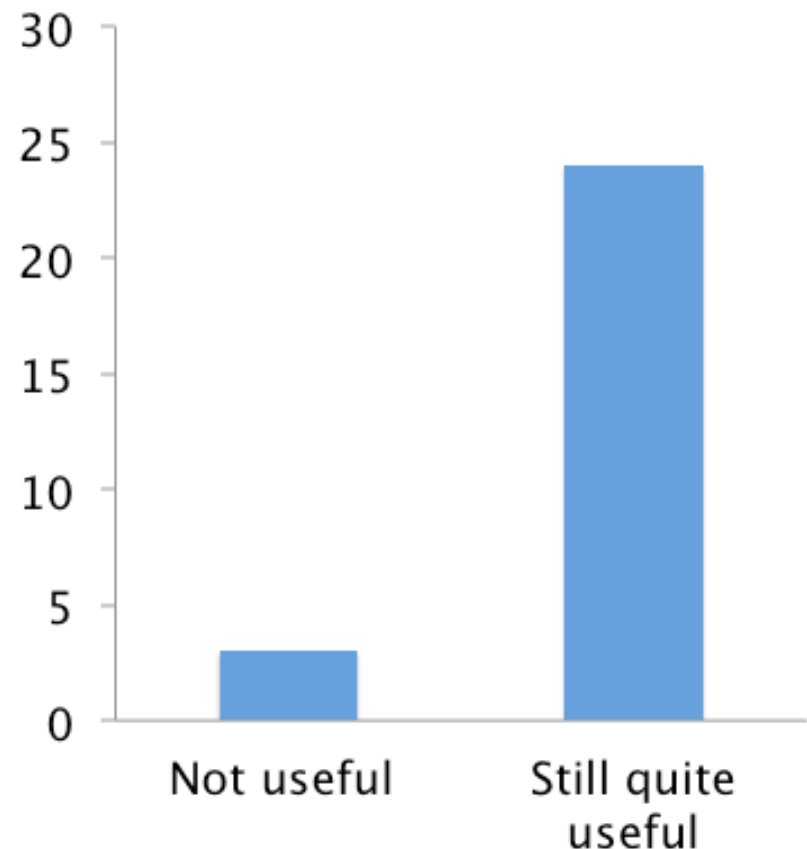
- *“Other – to procrastinate because it’s fun to check yourself” (4 students)*
- *“To help explain the topic to others” (1 student)*

## Assessment feedback (2/3)

Students were asked to gauge the usefulness of exercises they already had access to on MITx:

- *“Super useful to have it all consolidated in one place”*
- *“Looking at it by topic outside of MITx site helps affirm you really know it”*
- *“This is more concise and easier to find”*
- *“Useful because I don’t have the fear of wrong submission”*
- *“I can’t get access to MITx problems if I’m not taking the class”*
- *“I probably will have forgotten how to do all these problems after two weeks so good to have them on Crosslinks”*

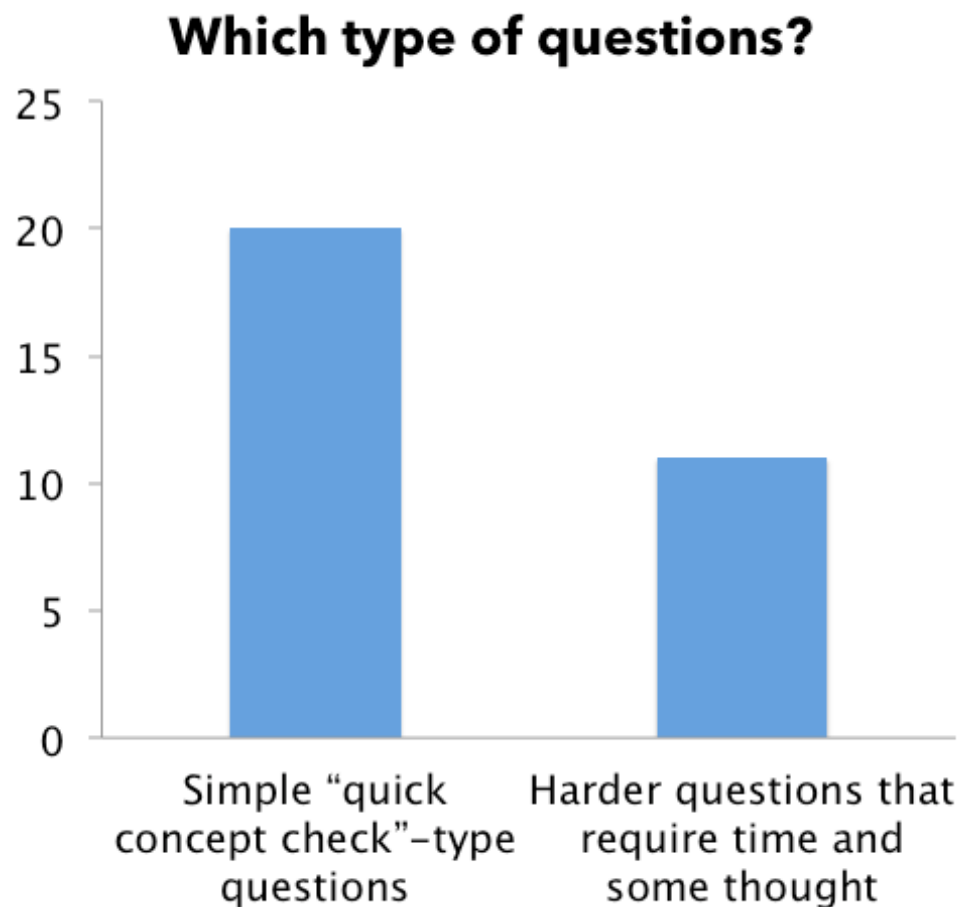
### How useful are duplicates?



# Assessment feedback (3/3)

Students were asked to indicate the preferred type of exercise (easy concept-check vs. harder types)

- *“Hard problems only if we have solutions”*
- *“Can we also get explanations? For a lot of problems on MITx, you can’t see explanations when you’re right or wrong.”*



# Qualitative feedback

## Key insights from students:

- Students like modularity
  - *“I like it that things are organized by topic. It’s more concise.”*
- Students like aggregation
  - *“It’s so useful to have everything in one place.”*
- Students like the specific MIT angle
  - *“It’s good to know that all this has been edited and vetted by MIT people, so I know it’s going to be useful for my MIT work.”*
- Students do care about the big picture, even if it’s not materially impactful
  - *“It’s interesting, and I think it must be subconsciously helpful when I’m learning it, but I don’t think it’ll actively lift up my grade. But I do think about how things connect together.”*

# Acknowledgements

- Lord Foundation
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- Jeff Merriman + ODL team
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