

# Adaptive Assessments in a HarvardX Course

Andrew Ang

[andrew\\_ang@harvard.edu](mailto:andrew_ang@harvard.edu)

Yigal Rosen, Ilia Rushkin, Glenn Lopez, Dustin Tingley (Harvard VPAL Research)  
Colin Fredericks (HarvardX)  
Mary Jean Blink (Tutorgen)

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# About us

HarvardX

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TutorGen, Inc.  
*A Revolution in Learning*



## Super-Earths And Life

Learn about alien life, how we search for it, and what this teaches us about our place in the universe.



Self-Paced

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- I would like to receive email from Harvard University and learn about other offerings related to Super-Earths And Life.

# Outline

- 1 Background
- 2 Implementation
- 3 Results
- 4 Future directions

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## Motivating adaptivity in MOOCs

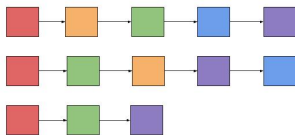
MOOC learners come from diverse educational backgrounds, and have different reasons for taking a course. How can we more effectively cater to a large, diverse population?



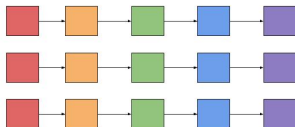
Engagement & Competency

# Scope of adaptivity: problem sequences

Experimental



Control



The next problem (or activity) is determined dynamically, based on real-time student response data.

# About the course



## Super-Earths And Life

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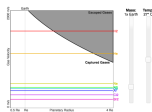


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- *Super-Earths And Life is a course about alien life, how we search for it, and what this teaches us about our place in the universe.*
- Course launch: October 2016
- Version 3; pre-existing course material authored in edX
- Custom javascript problems



Simulation by GCM: Frederik VDL, Harvard

Enroll

# Project goals and scope

- Serve edX problems in a dynamically generated sequence
- Minimum viable product / pilot study; meant to:
  - investigate technology requirements
  - explore implications for course (re)design
  - establish the foundation for future study of adaptive functionality in MOOCs on learning outcomes, engagement and course drop-out rates



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# Adaptive assessment appearance in edX course

The screenshot displays the edX course interface. On the left is a navigation menu with sections like 'Introduction', 'The Chemistry of Life', 'Exoplanets', and 'Life on Super-Earths'. The main content area shows an assignment titled 'Assignment' with a 'Previous' button and a 'Next' button. Below the assignment title, it indicates 'HOMEWORK [EXTERNAL RESOURCE] (0.0 / 25.0 points)'. The assignment is titled 'Wobble Method' and is worth 4.35 points. The question asks the user to imagine a star system with planets that orbit edge-on to us, as shown in a diagram. The diagram compares a 'Distant System' and 'Earth's System'. In the 'Distant System', a star is on the left and a planet is on the right, with a dashed line representing the line of sight. In the 'Earth's System', a star is on the right and a planet is on the left, also with a dashed line representing the line of sight. Below the diagram, the question asks to select all that apply: 'While a planet orbits this star, we will see a greater Doppler shift in the star's spectrum if...'. The options are:
 

- The planet has greater mass, but the same size
- The planet is larger, but has the same mass
- The planet orbits closer to its star
- The planet moves faster in its orbit
- The star is less massive
- The star is not as bright
- The star is closer to us on Earth

 At the bottom, there is a 'Submit' button and a 'Need Help?' button. The interface also shows 'Total points earned: 14.30' and 'You have used 2 of 5 attempts'.

Adaptive assessment tool is embedded as a graded external tool assignment.

# Nested iframe implementation

The screenshot illustrates a nested iframe implementation within an edX course. The main page is an assignment titled "Exoplanets - How do we Find Exoplanets?". It features a navigation menu on the left and a main content area. The main content area contains an "Assignment" section with a "Bookmark this page" link and the "edX" logo. Below this is a "HOMEWORK (EXTERNAL RESOURCE) (14.3 / 25.0 points)" section, which is an "LTI tool". This LTI tool contains an "edX (XBlock)" titled "Worksheet: Method" (worth 1.00 point). The worksheet asks the user to "Imagine a star system with planets that orbit edge-on to us, as shown in the diagram below (not to scale)." and includes a diagram showing a "Distant System" and "Earth's System" with a star and a planet. Below the diagram is a multiple-choice question: "Write a planet orbits this star, we will see a greater Doppler shift in the star's spectrum if...". The options are:
 

- The planet has greater mass, but the same size
- The planet is larger, but has the same mass
- The planet orbits closer to its star
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 The interface also shows a "Submit Answer" button, a "You have used 2 of 5 attempts" message, and a "View Feedback" button. The URL at the bottom is "https://courses.wisc.edu/803/block-v1/16".

# UI components

1 2 3 4 Total points earned 8.55

### Wobble Method

(2.15/5 points)  
Imagine a star system with planets that orbit edge-on to us, as shown in the diagram below (not to scale).



**Distant System** **Earth's System**

Select all that apply.

While a planet orbits this star, we will see a greater Doppler shift in the star's spectrum if...

- The planet has greater mass, but the same size
- The planet is larger, but has the same mass
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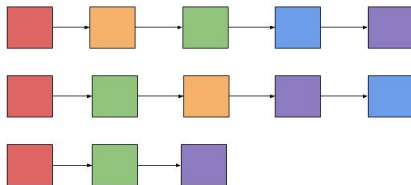
You have used 2 of 5 submissions

[Shareable link](https://courses.edx.org/block/block-v1-H) <https://courses.edx.org/block/block-v1-H>

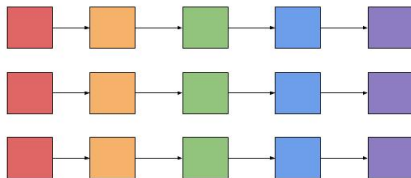
Nav bar (upper left), score (upper right), sharable link (lower left), next activity (lower right)

# Experimental setup

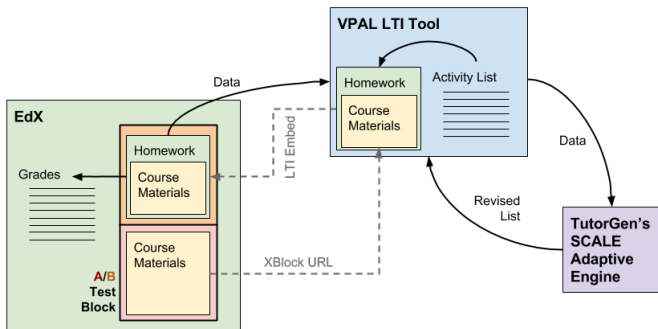
Experimental



Control



# Course design for adaptive experimentation



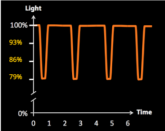
All problems for adaptive sections are kept in the control group portion of an A/B testing block (Content Experiment). Experimental group portion contains an LTI component.

# Javascript sensors embedded in problems

Using the Light Curve

0.0/10.0 points (graded)

Observations of a nearby star show regular dips in the light curve, indicating the presence of a planet. From this information, you know that its radius is 73,000 km. Use the light curve and other information shown below to determine the size of the planet.



The graph shows a light curve with a y-axis labeled 'Light' ranging from 0% to 100% and an x-axis labeled 'Time' ranging from 0 to 6. The light intensity is constant at 100% except for regular, periodic dips that reach approximately 75%.

Calvin Fredericka, Harvard

Enter the planet's radius in kilometers.

 km 

4

You have used 1 of 10 attempts



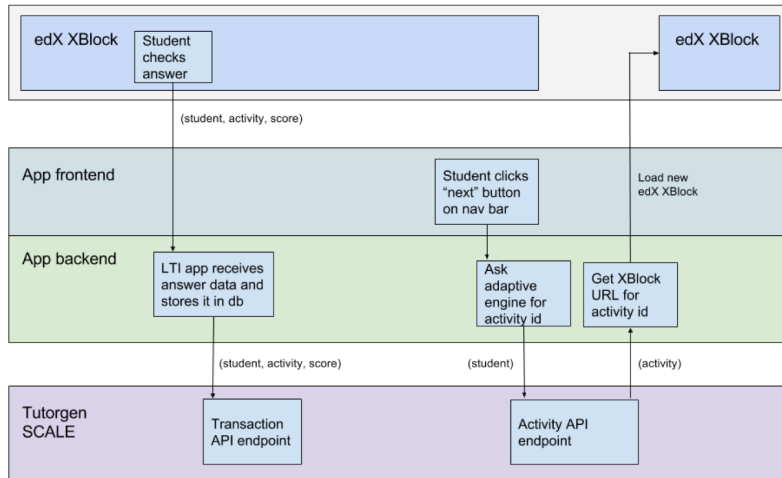
Javascript embedded in problem sends data to adaptivity web application (Django, AWS) on problem submit event.

# Adaptive engine

- Tutorgen adaptive engine (SCALE: Student-Centered Adaptive Learning Engine)
- Uses a variant of Bayesian Knowledge Tracing to make activity recommendations
- Implements 2 API endpoints:
  - post transaction
  - get activity



# Event sequence cascade: a bridge for adaptivity



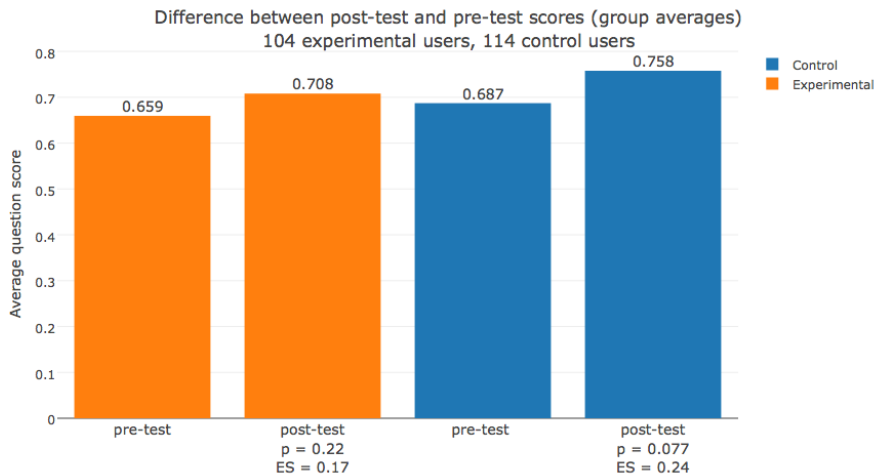
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## Preliminary findings

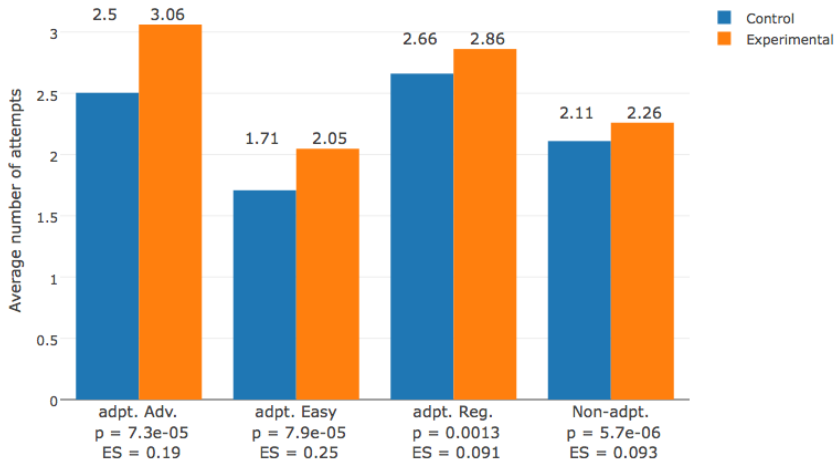
- Students who experienced adaptivity showed more persistence by giving more attempts per problem (presumably, because adaptively served problems are more likely to be on the appropriate current mastery level for a student)
- Higher efficiency of learning: students go through the course faster and attempt fewer problems, since the problems are served to them in a targeted way
- Technological challenge: getting real-time student activity from problems
- Implementing adaptivity in a course requires a large amount of new content and learning objective tagging

# Comparing difference in learning gains

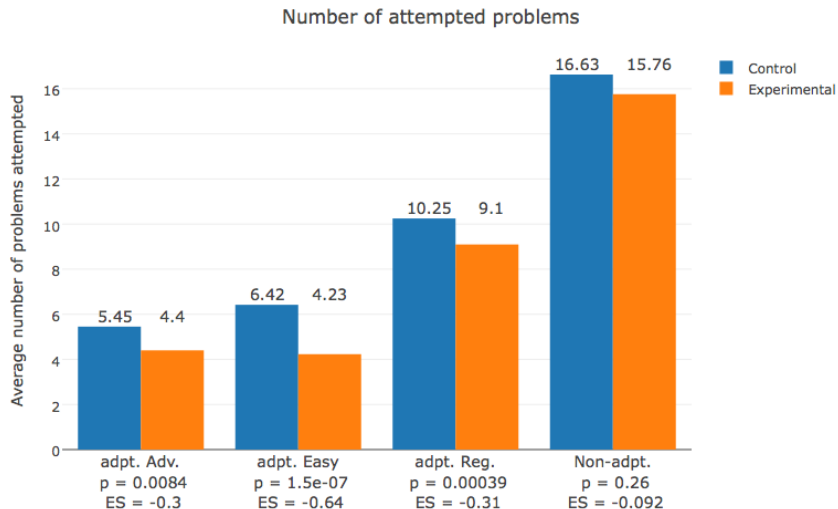


# Number of attempts per problem

Persistence: number of attempts per problem per user



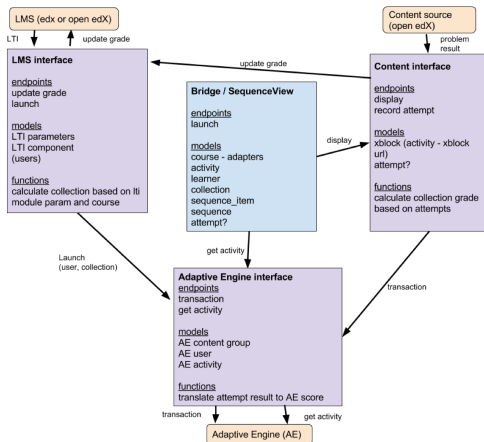
# Number of problem attempts



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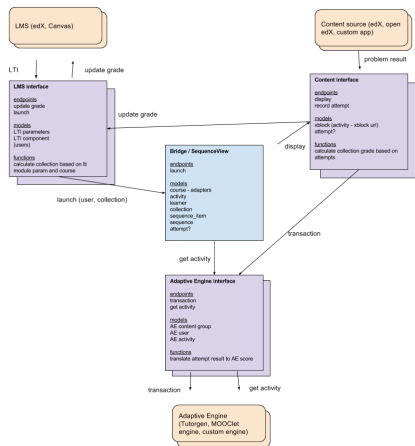
# Generalizing content source interface



Using Open edX as a LTI provider for content display and student response data



# Interfacing with multiple external systems



3 components: LMS (edX/Canvas), adaptive engine, content source

# Streamlining course integration and setup

- How can we streamline the process of setting up a course to enable adaptivity?
- Possible API and/or UI for managing content and learning objective tagging

# Upcoming course deployments



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## Data Science Essentials

Explore data visualization and exploration concepts with experts from MIT and Microsoft, and get an introduction to machine learning.



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## Essential Statistics for Data Analysis using Excel

Gain a solid understanding of statistics and basic probability, using Excel, and build on your data analysis and data science foundation.



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- I would like to receive email from Microsoft and learn about other offerings related to Essential Statistics for Data Analysis using Excel.

# Open Source Adaptive Learning Workshop

- VPAL Research is partnering with Microsoft to develop an open source adaptive engine for use in upcoming course deployments.
- Workshop objectives: engage participants in reviewing the adaptive engine algorithm, the research design of content experiments, and the architecture of our implementation
- Thursday, June 1st, 11am-2pm EST
- Join in-person or virtually via Skype
- Contact [yigal\\_rosen@harvard.edu](mailto:yigal_rosen@harvard.edu) if interested